



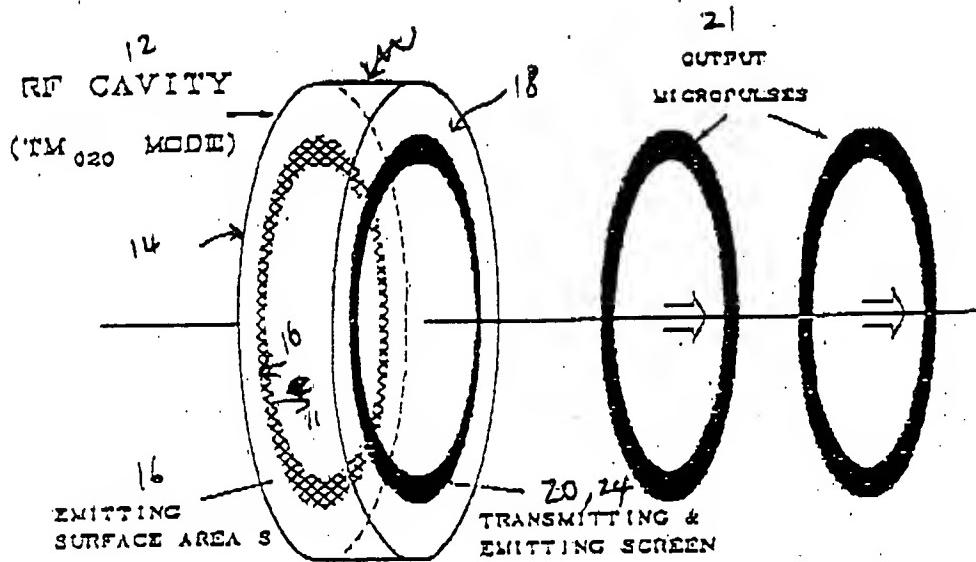
22
oscillating
means
28
magnetic
field means

electron gun

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11 : electrons between 16 and 20

Figure 1: Perspective view of the micropulse gun for a hollow beam in the TM_{020} mode. The inner conductor is not shown.

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TM-020 Mode Cavity with Inner Cylinder

10 electron gun

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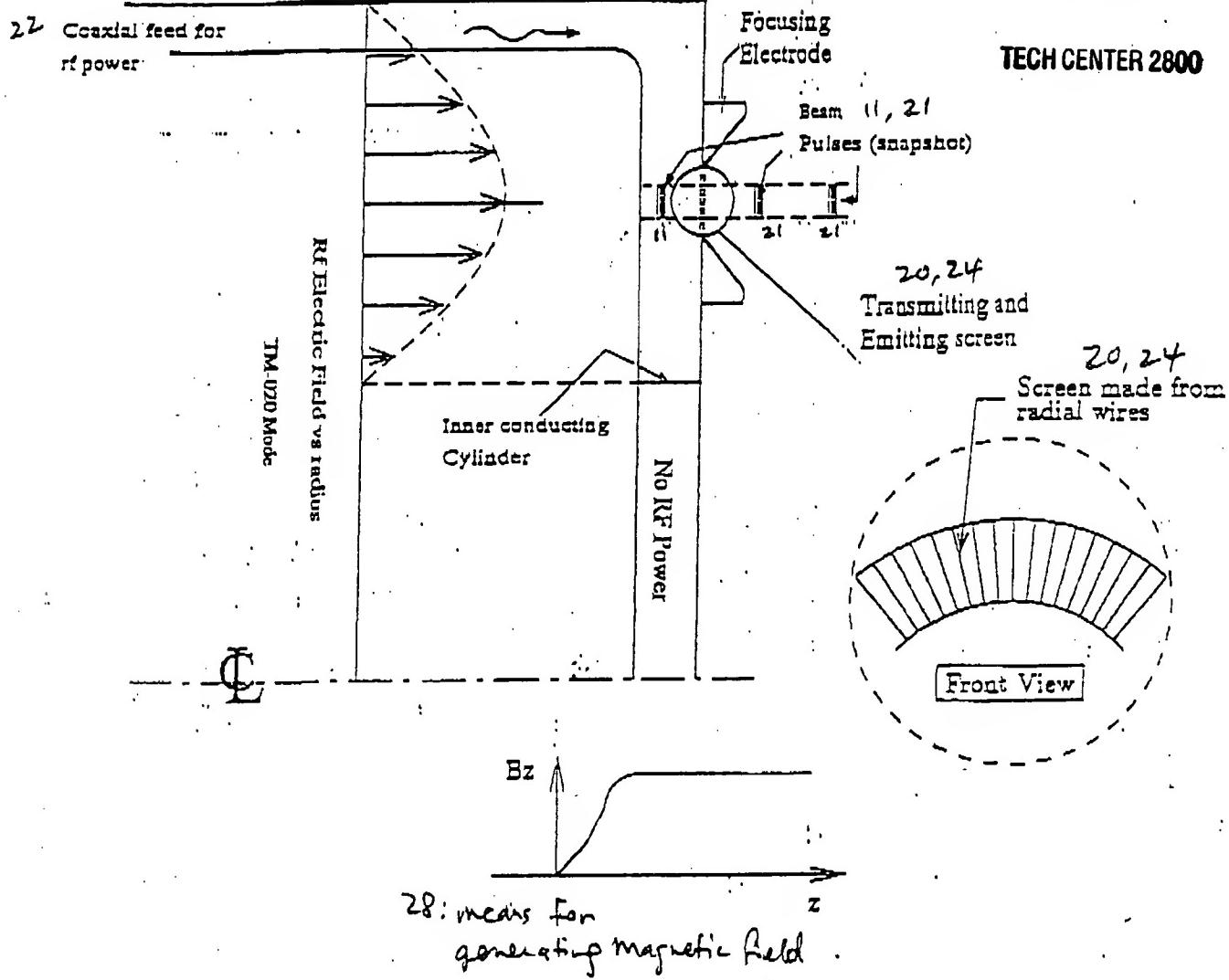
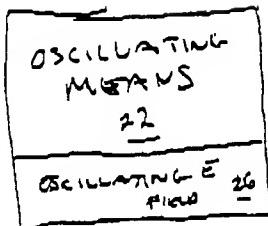


Figure 2: Schematic of rf gun operating in TM₀₂₀ mode.

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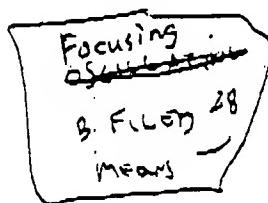
RF cavity
(side view)

10

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Emitting
surface S
Coeff. = δ_1

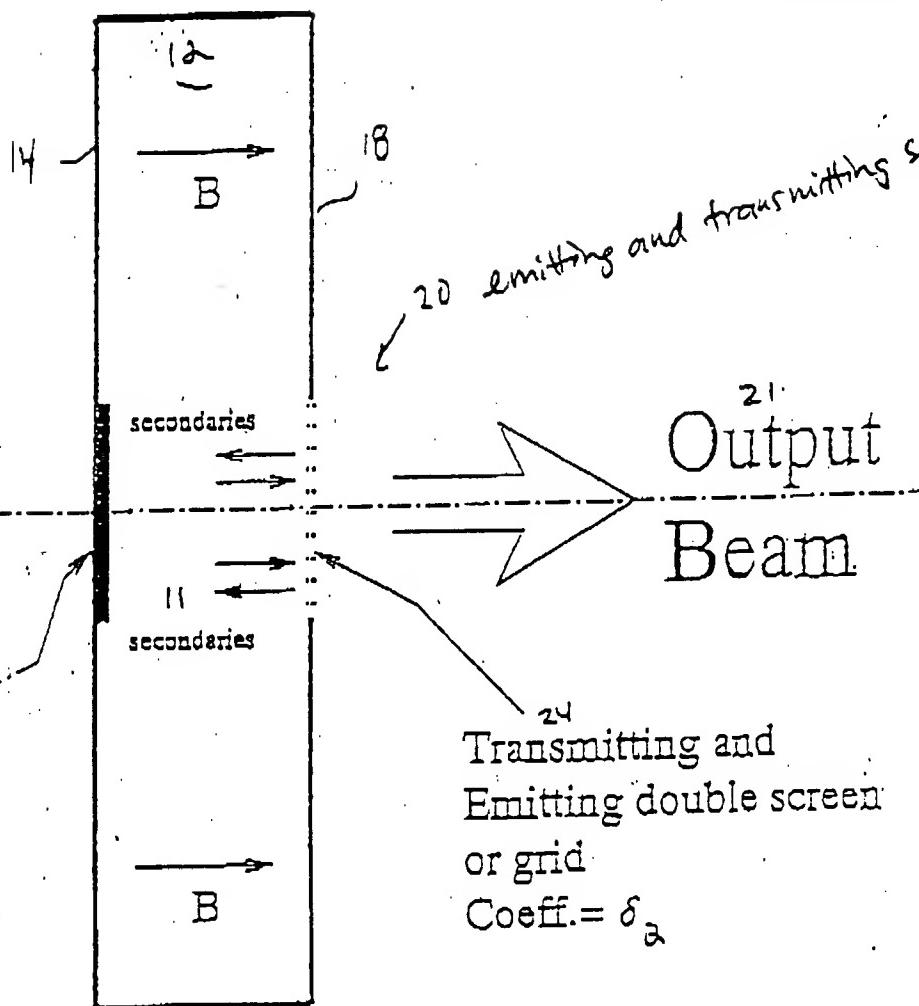


Figure 3: Schematic of micropulse gun for solid beam (TM_{010}) mode. A coaxial feed is used for rf input (not shown).

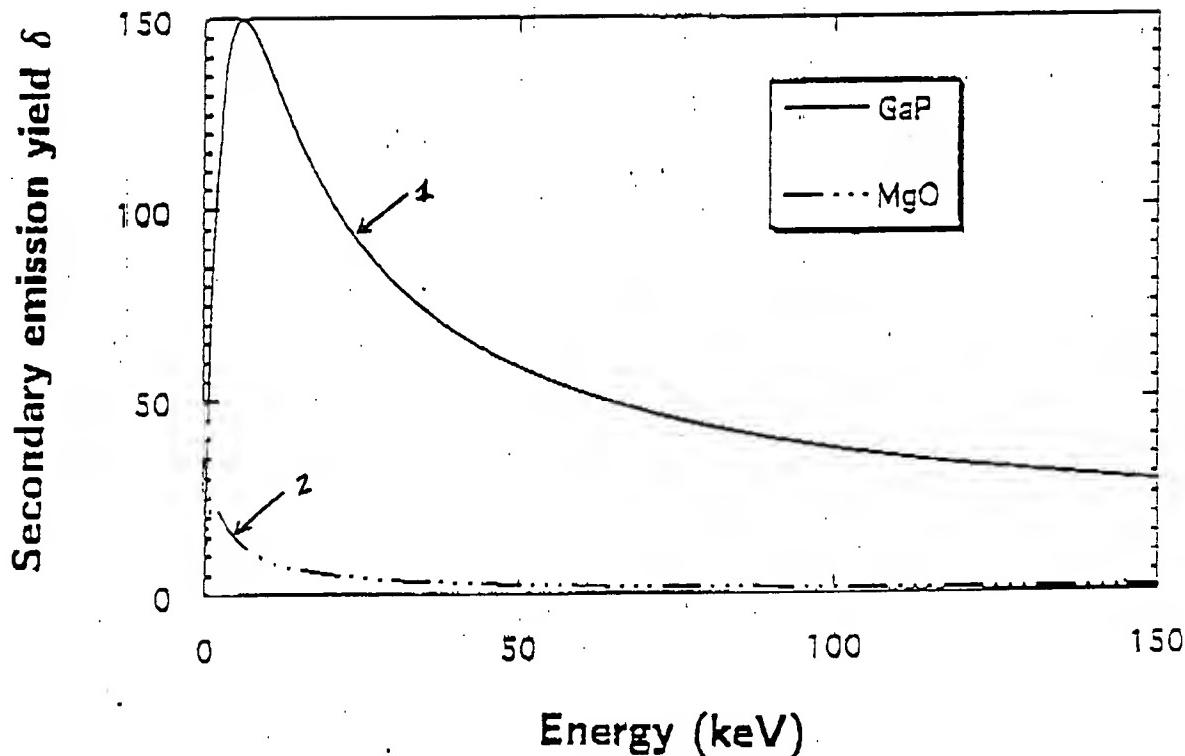
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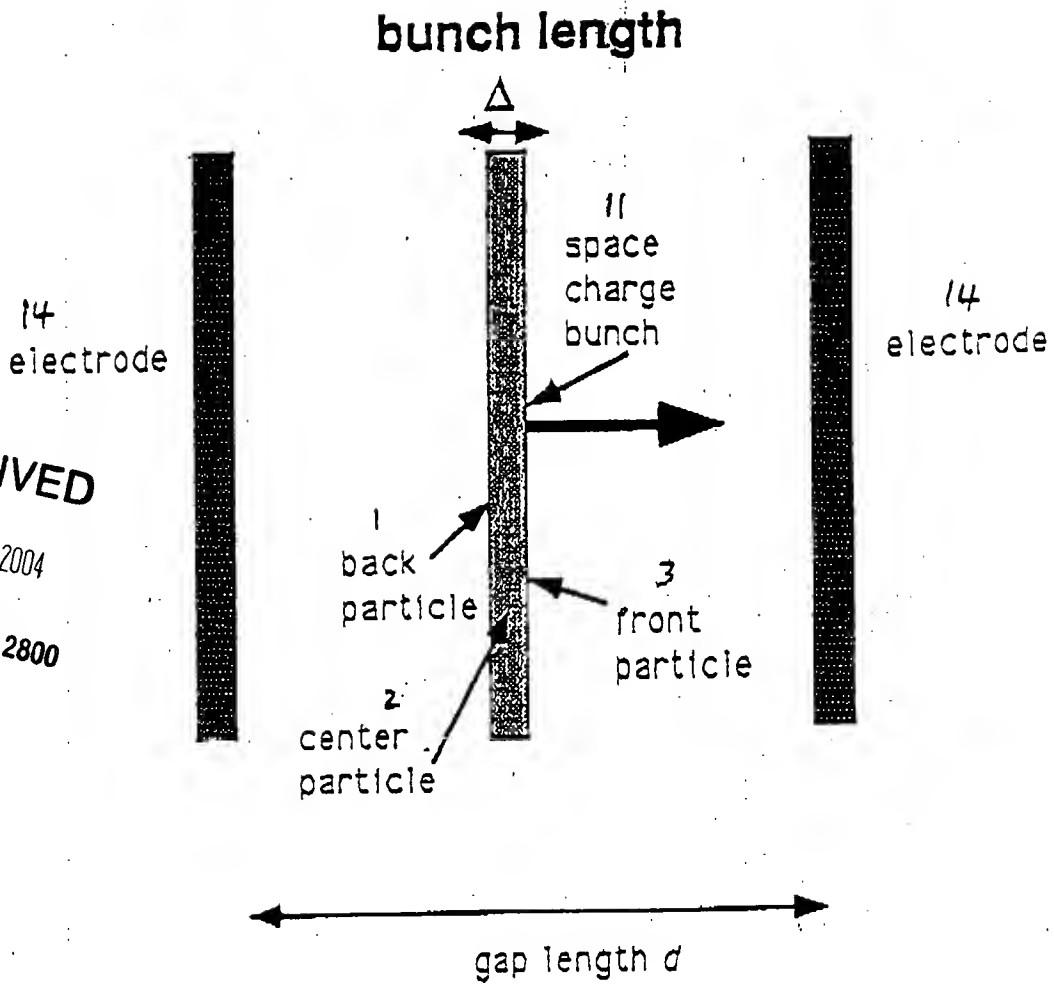
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1: Secondary emission yield of GaP
2: MgO

Figure 4: Secondary electron emission yield curve for GaP and MgO

SUBST 170 TE FIGURE



- 14 : emitting electrodes
- 11 : electron bunch
- 1 : A back particle/electron
- 2 : " center "
- 3 : " front "

Figure 5: Schematic drawing of model used in theoretical analysis.

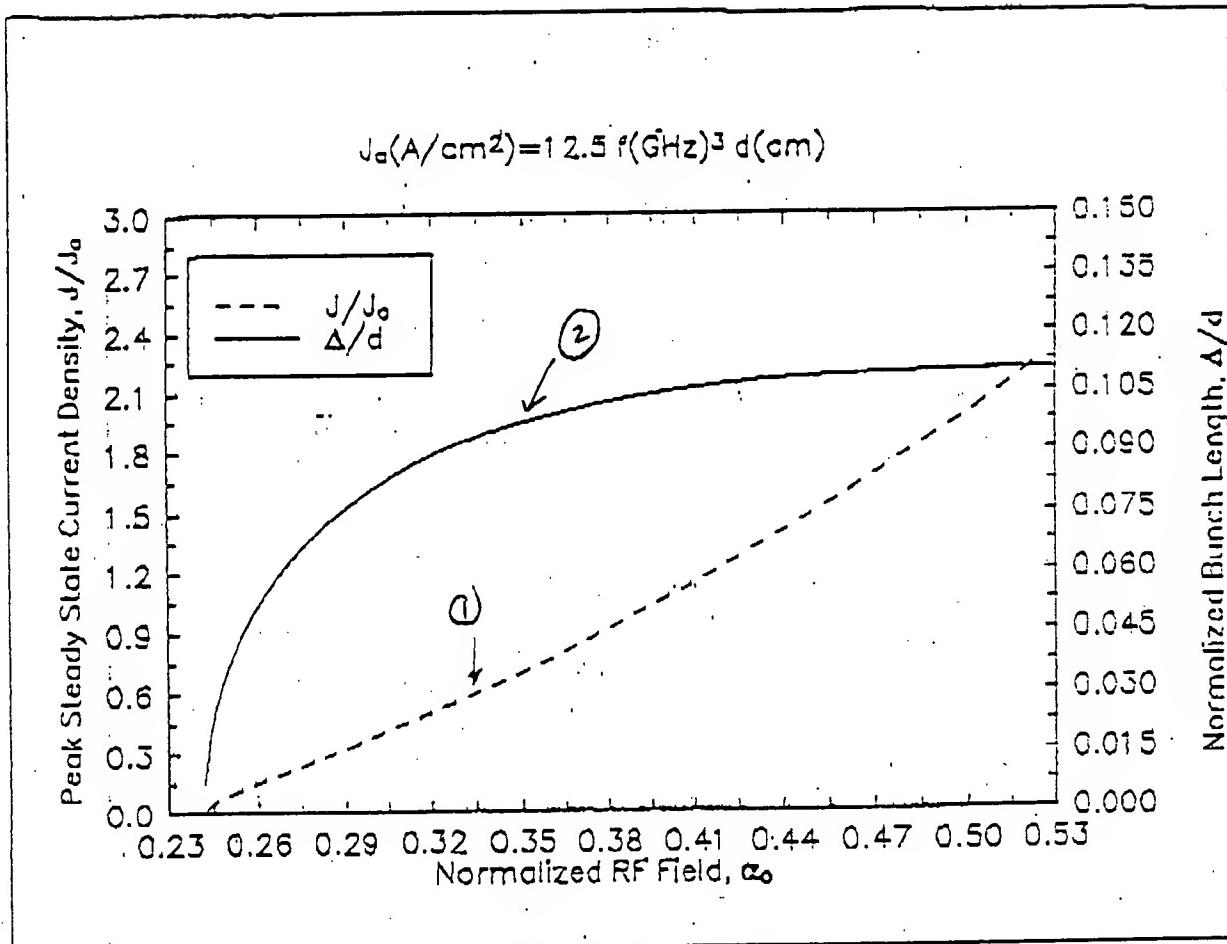
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- ① Plot of ^{normalized} Peak current density at steady state versus RF field
- ② " ^{normalized} electron bunch length versus RF field.

Figure 6: Steady-state current density and bunch length vs. rf field, all parameters are normalized.

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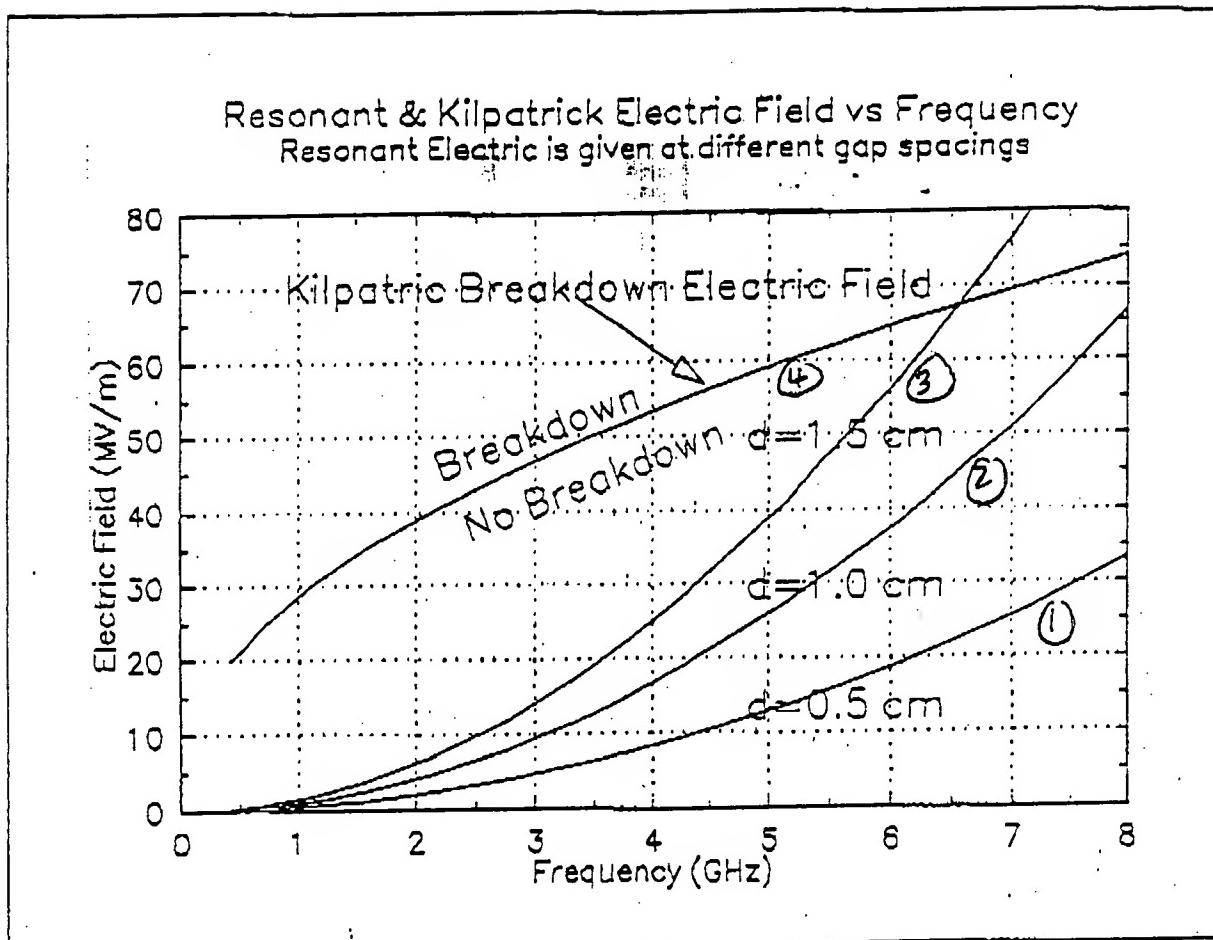


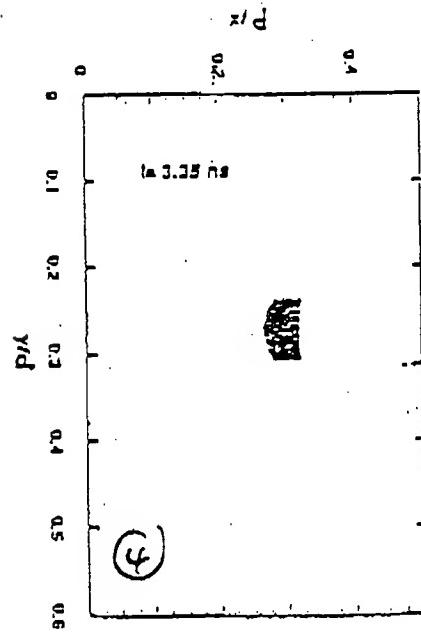
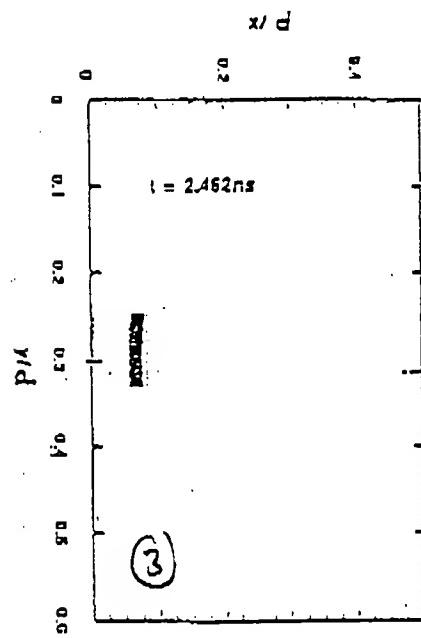
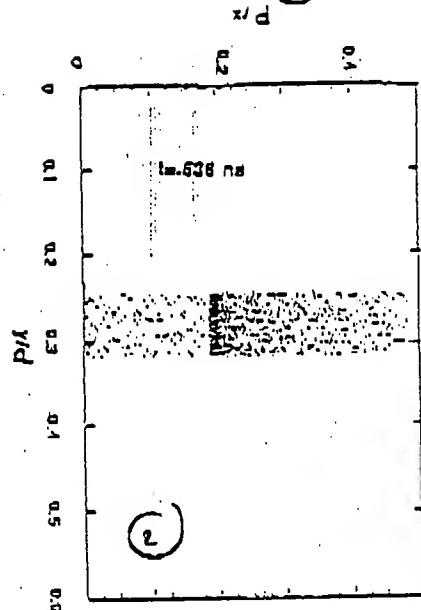
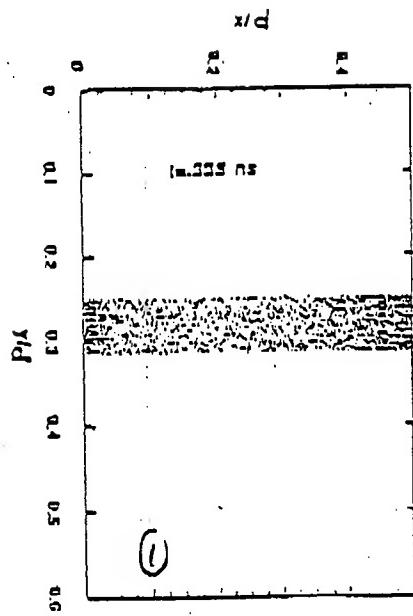
Figure 7: Plot of resonant electric fields for $\alpha_0 = 0.453$ and various gap spacings. Also shown is the critical Kilpatrick electric field as a function of rf frequency.

SUBSTITUTE FIGURES



1.3 GHz, xy plot

- (1) Plot of electron distribution in the cavity at $t = 0.335\text{ns}$.
 (2) at $t = 0.636\text{ns}$
 (3) at $t = 2.462\text{ns}$
 (4) at $t = 3.35\text{ns}$



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Figure 8: Series of time "snapshots" for a 1.3 GHz, $d = 0.5$ cm cavity using the two-dimensional PIC code with secondary emission. Note the rapid particle build-up and bunching by phase selection. Electrons traverse the horizontal axis. On the vertical axis emission is limited to the region 0.25 to 0.32 cm.

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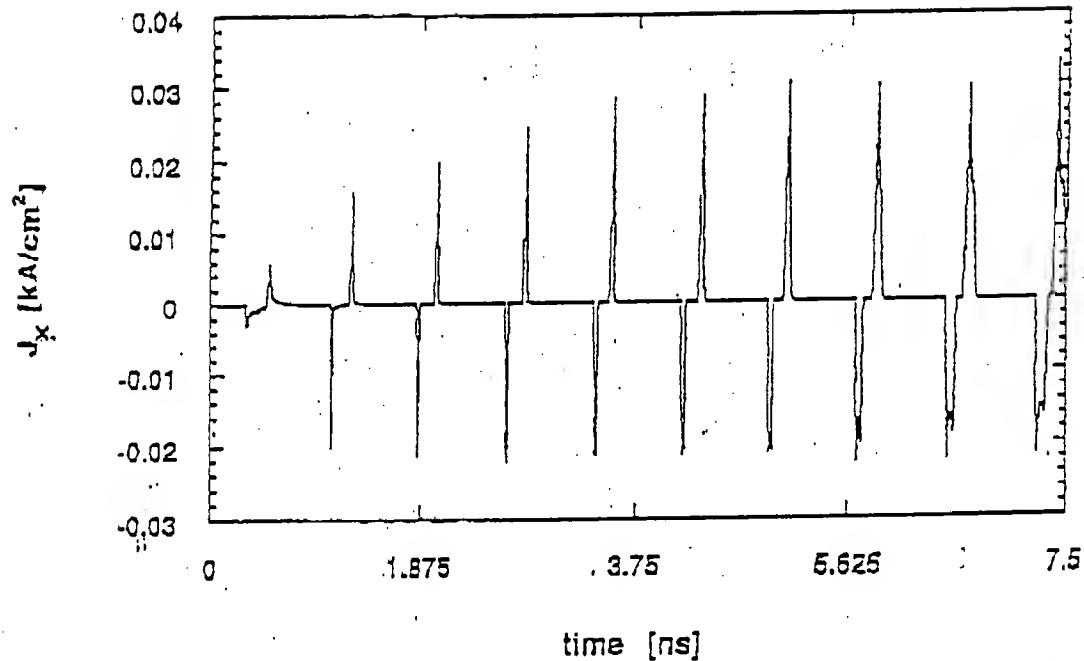


Figure 9: Plot of current density vs. time for simulation with rf frequency 1.3 GHz, voltage amplitude 4.3 kV, $d = 0.5$ cm, and $\alpha_0 = 0.453$.



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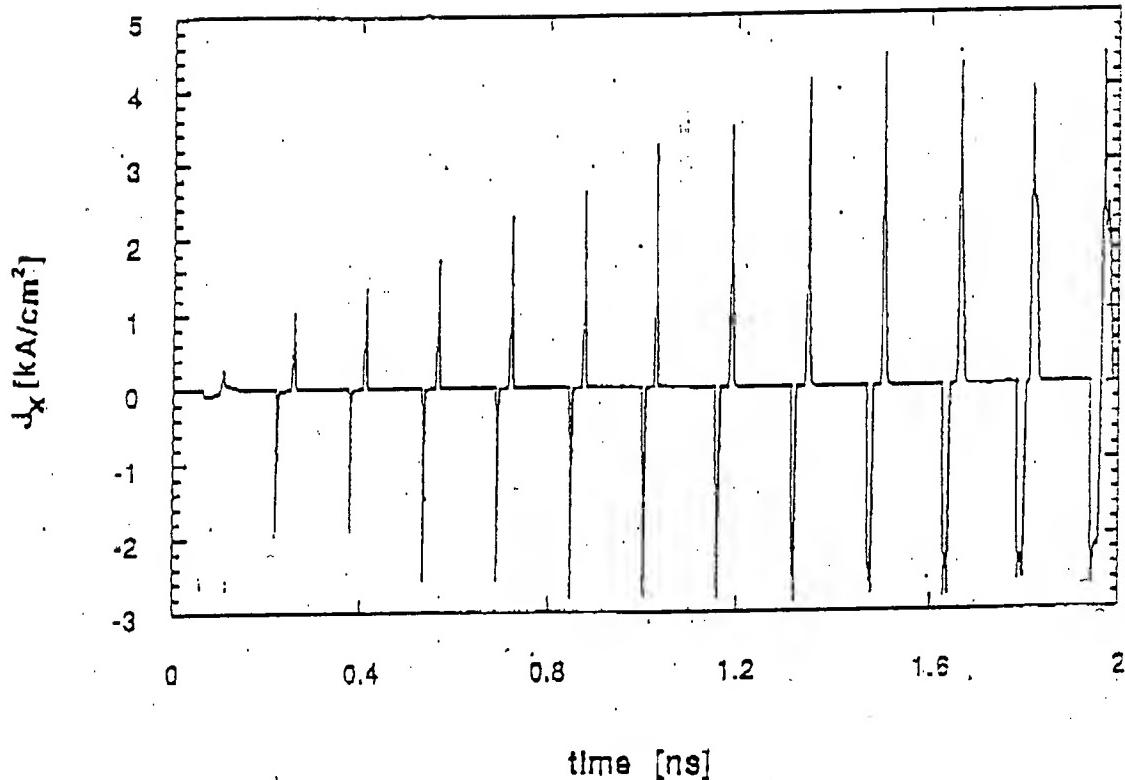


Figure 10: Plot of current density vs. time for simulation with rf frequency 6.4 GHz, voltage amplitude 105 kV, $d = 0.5$ cm, and $\alpha_0 = 0.453$.

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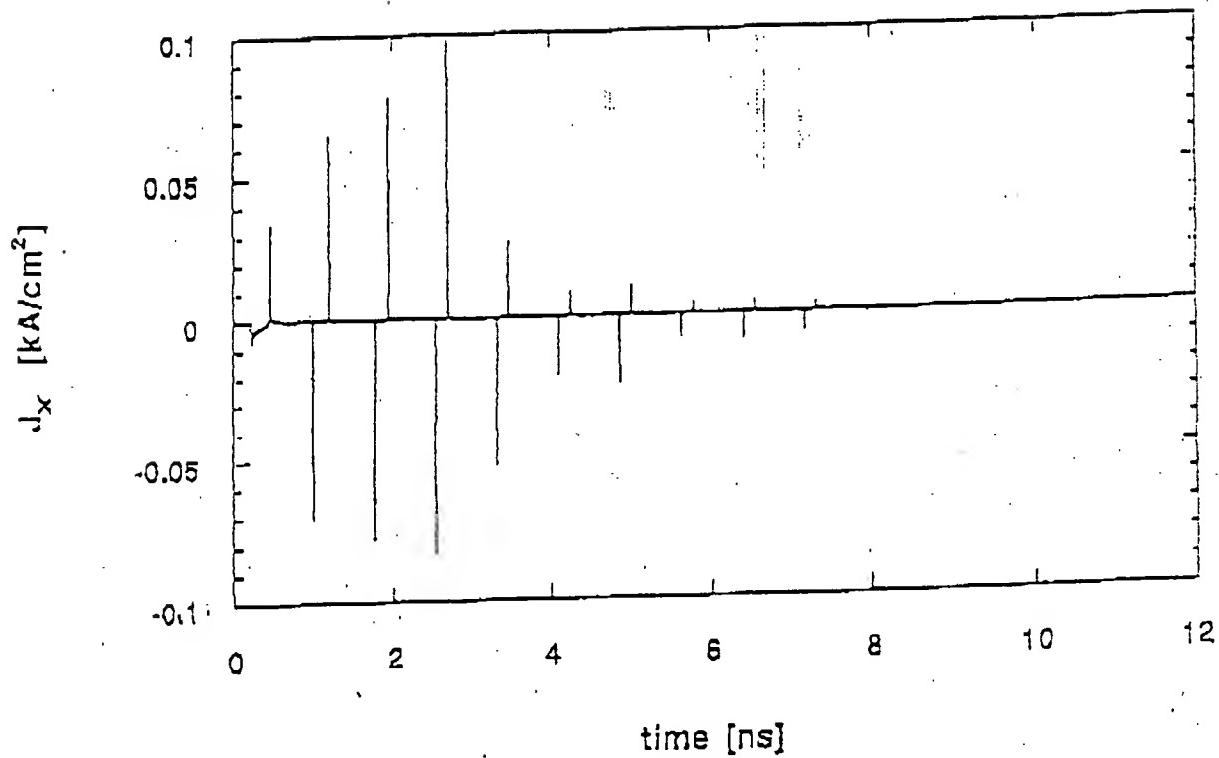


Figure 11: Current density in kA/cm^2 for an off-resonance $d = 0.5 \text{ cm}$ cavity with frequency 1.3 GHz and higher voltage 9.8 kV. Note that not only does current amplification not occur, but the steady-state current is zero.

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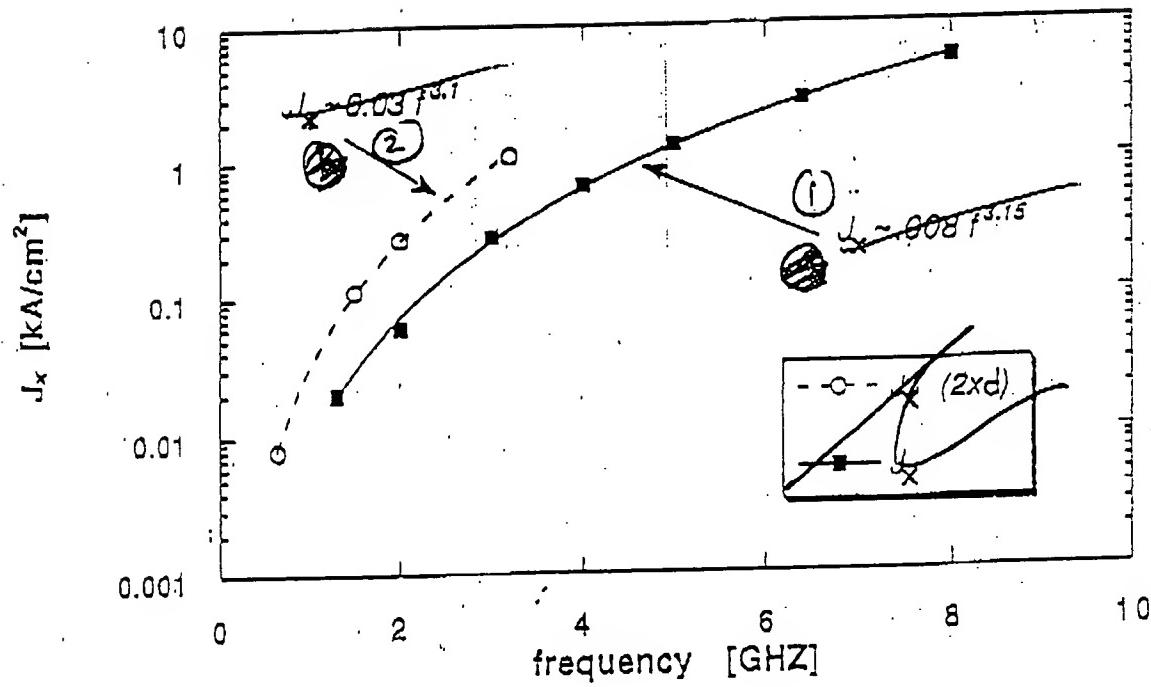


Figure 12: Steady-state current density vs. rf frequency for cavity with $\alpha_0 = 0.453$ and gap lengths of (1) 0.5 cm (solid line) and (2) 1.0 cm (dashed line)

is a fit using $J_x = 0.03 f^{0.1}$

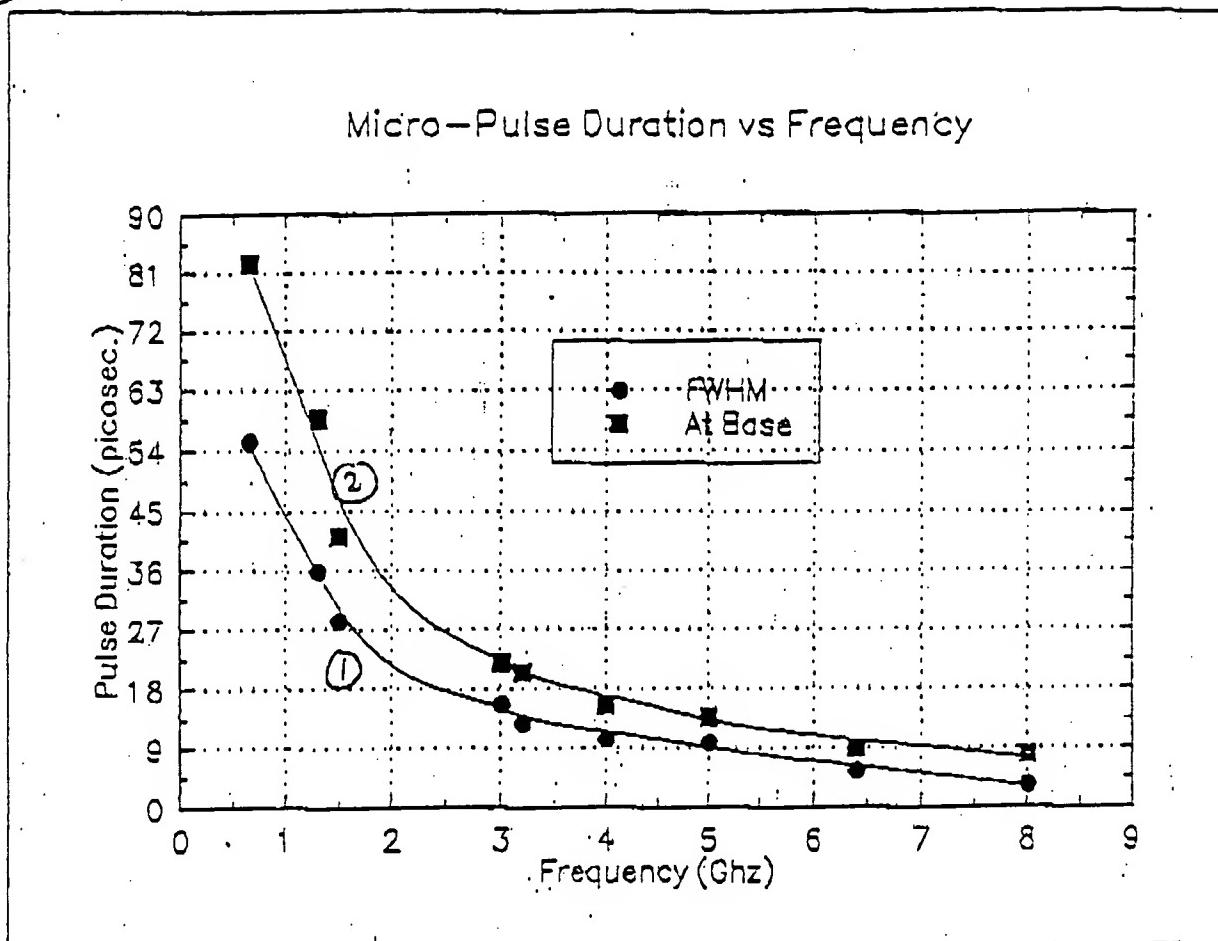
is a fit using
 $J_x = 0.008 f^{3.15}$

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(1) Electron micro-pulse full width at half maximum.
(2) " " " " " " the base of the pulse.

Figure 13: Micro-pulse duration vs. frequency for $\alpha_0 = 0.453$.

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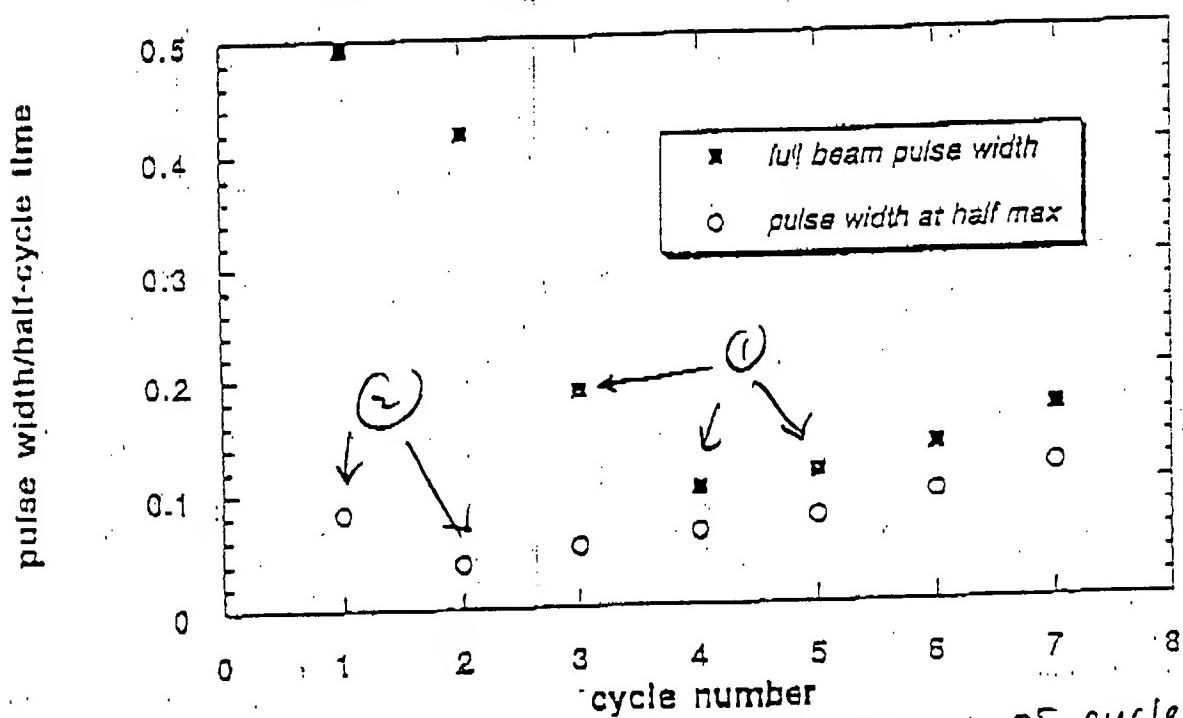
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1.3 GHz pulse widths normalized to rf half-cycle time



- ① (solid squares) Beam full width at different RF cycle
 ② (open circles) Beam full width at half maximum at different RF cycle.

Figure 14: Micro-pulse width (as a fraction of the half-cycle) vs. rf cycle number near the output grid. The full beam pulse width decreases with time, and reaches a minimum at the fourth rf cycle. After saturation there is a slight increase in pulse-width due to space-charge effects.

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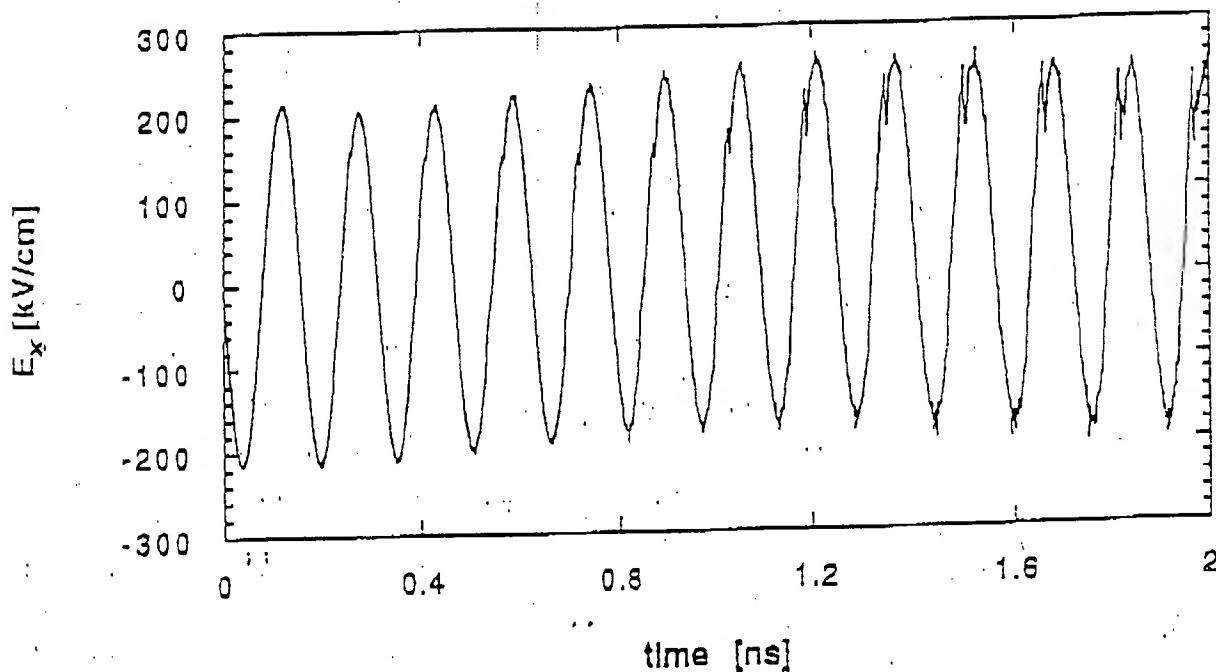


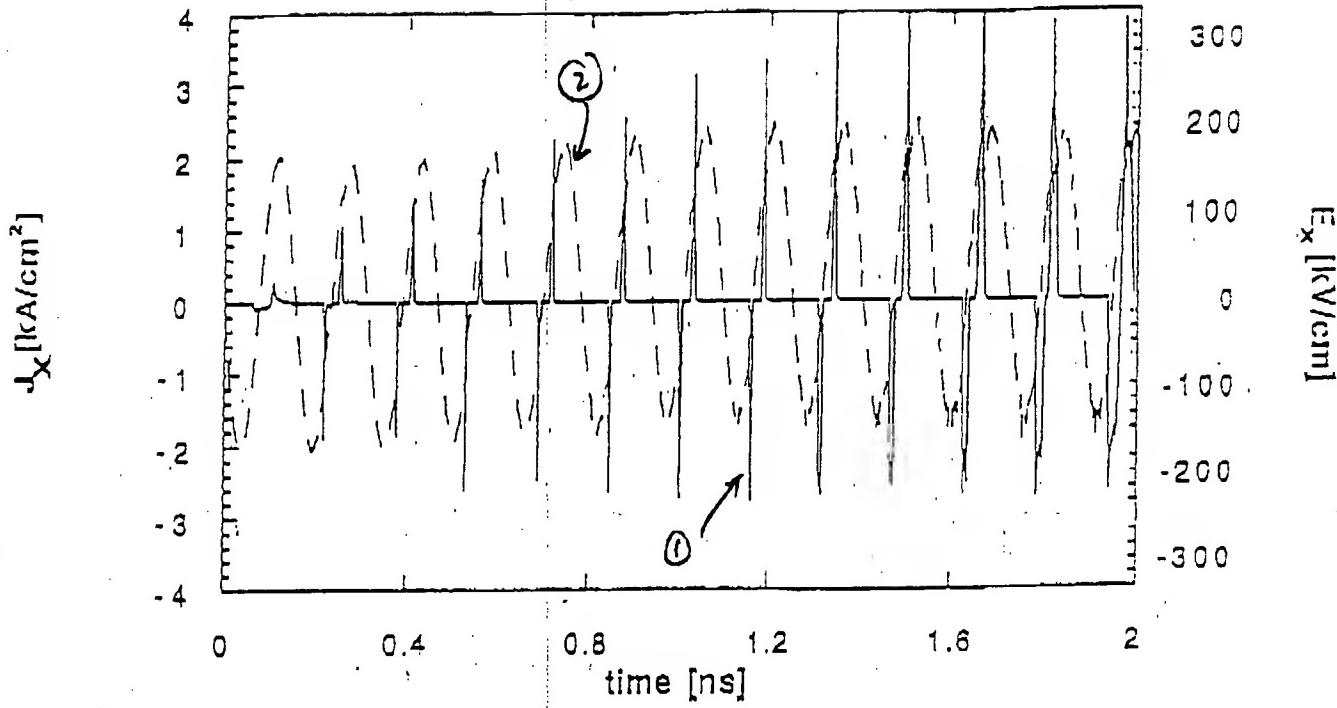
Figure 15: Longitudinal electric field in kv/cm as measured by a probe near the exit grid for the 6.4 GHz, 105 kV simulation.



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① ②
Figure 16: Plot of the current density in kA/cm^2 [solid line] and the longitudinal electric field [dashed line] for the 6.4 GHz, 105 kV simulation.

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Comparison of Theory and Simulation
cavity gap=d= 0.5 cm, J_o (A/cm²)=12.5 f(GHz)³ d(cm)

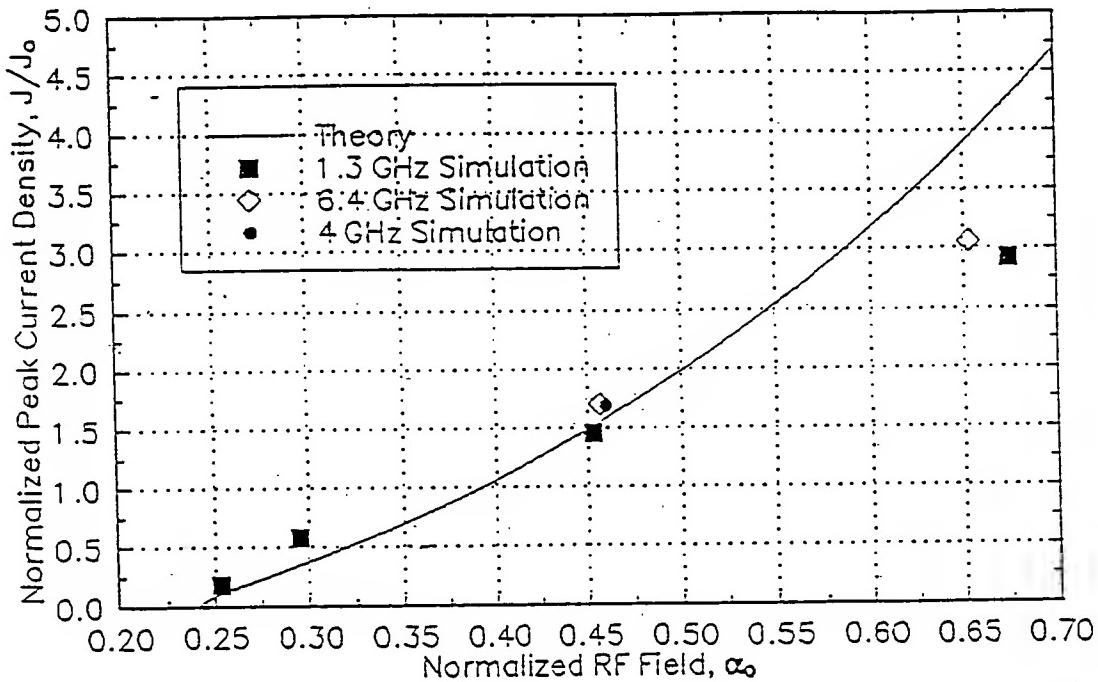


Figure 17: Resonant Tuning Curve (both simulation and theory) showing the tolerance of the micropulse electron gun.

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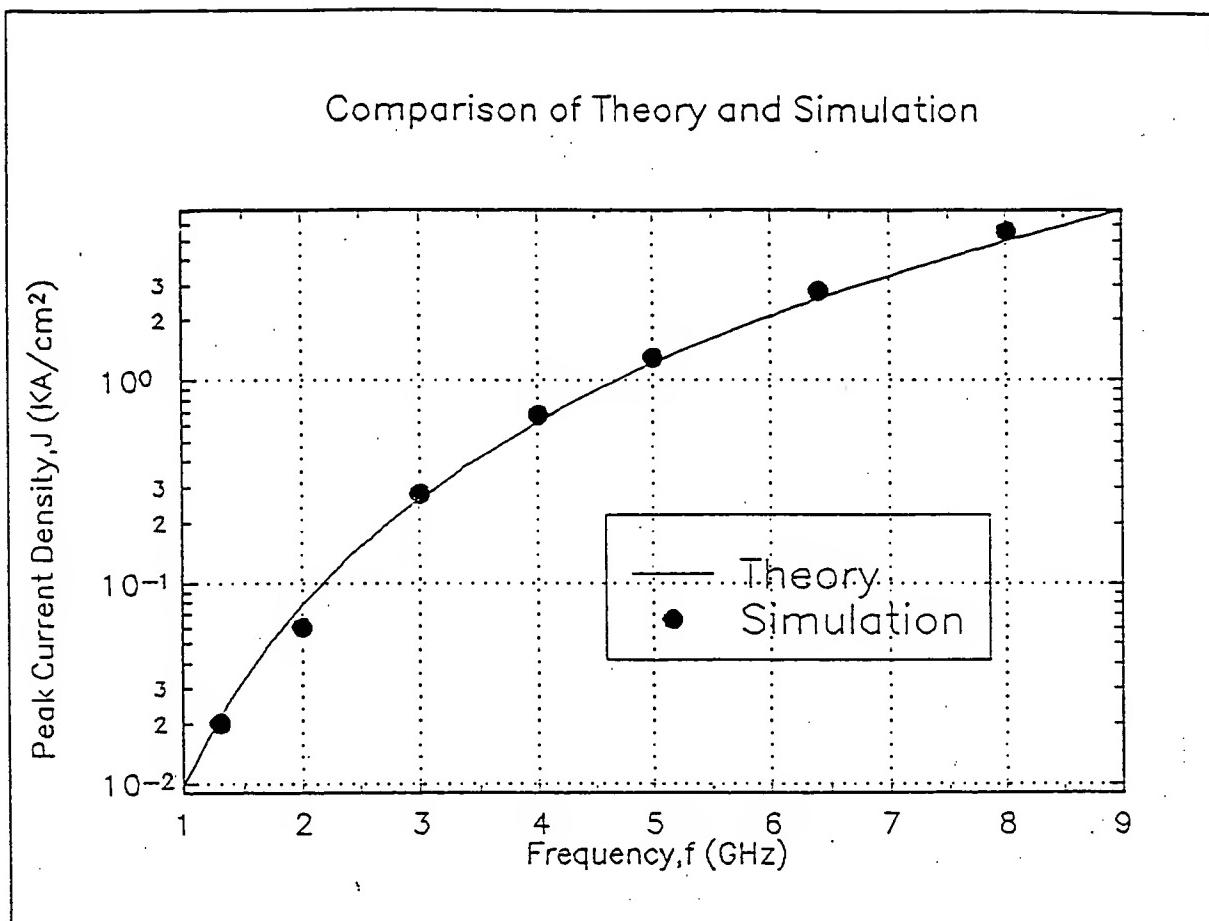


Figure 18: Comparison of peak current density in kA/cm^2 versus frequency for simulation and theory for a gap length of 0.5 cm and drive parameter $\alpha_0 = 0.453$.



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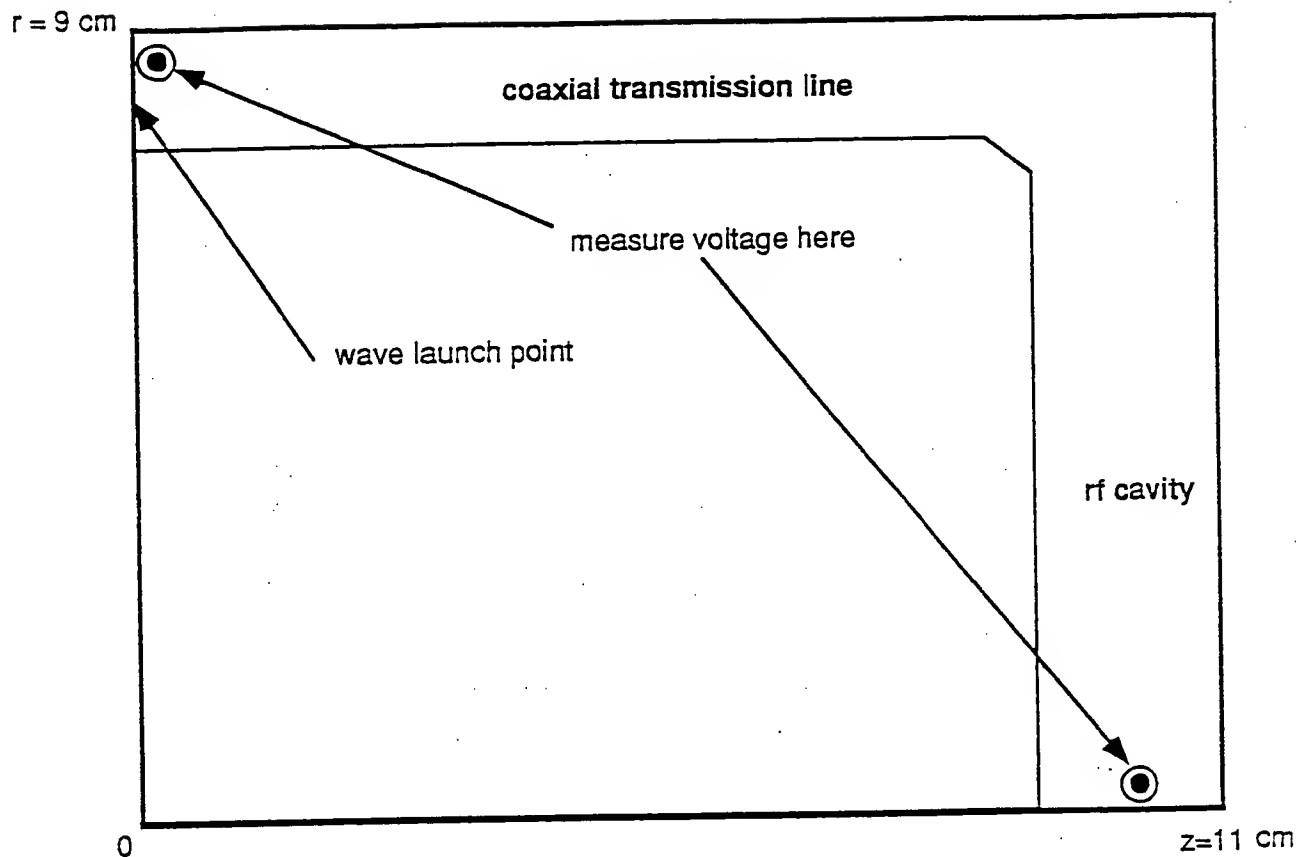


Figure 19: Side view of a cylindrically symmetric coaxial transmission line and cavity. An rf wave is launched at the left end of the coaxial line.

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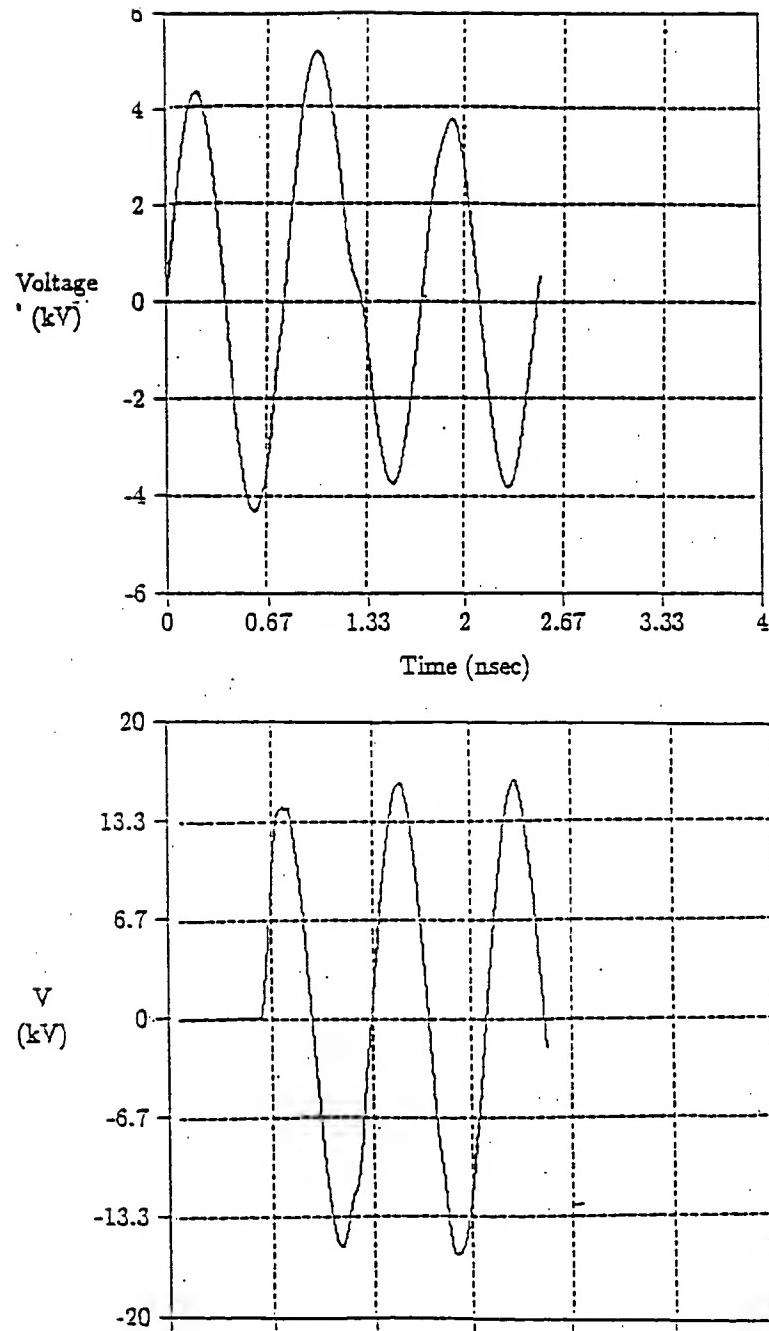


Figure 20: Resulting voltages for a TM_{010} cavity at 1.275 GHz (9 cm radius) with a one cm cavity gap and one cm coaxial gap. (top) voltage measured at entrance of coax, and (bottom) voltage measured at cavity center.

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Electric Field vs Radius for an Ideal and a Coaxially Fed Cavity
 TM_{010} mode at 1.275 GHz, Cavity Gap=1 cm, Coaxial Gap=1 cm

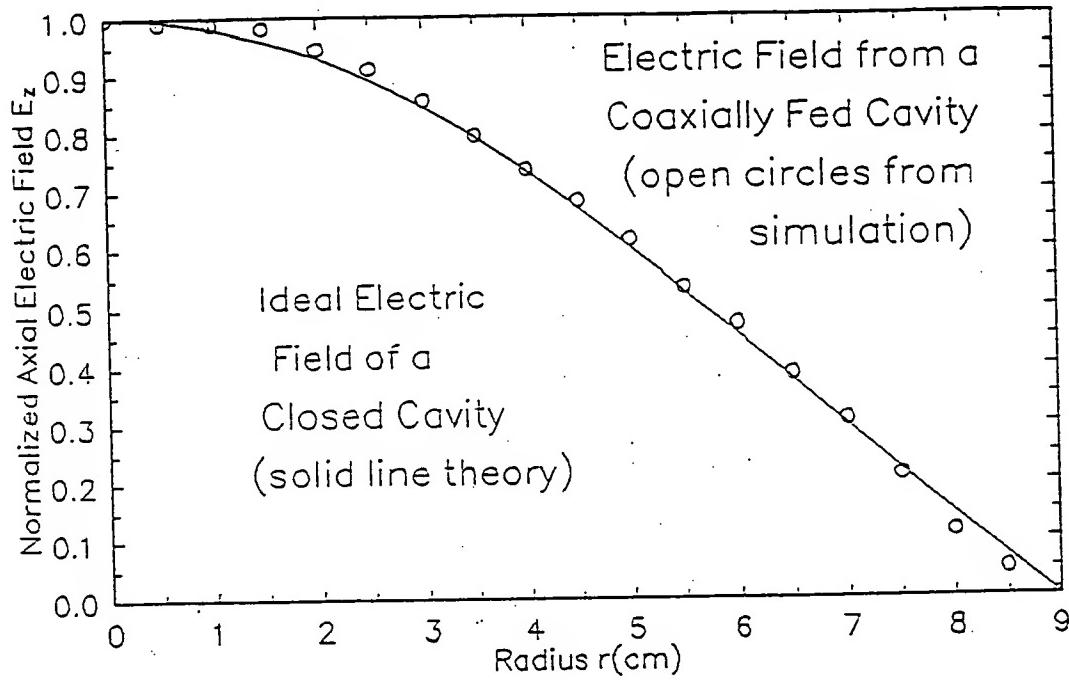


Figure 21: Electric field from a coaxially fed cavity (TM_{010} mode) showing simulation values (open circles) and theoretical curve for an ideal closed cavity.

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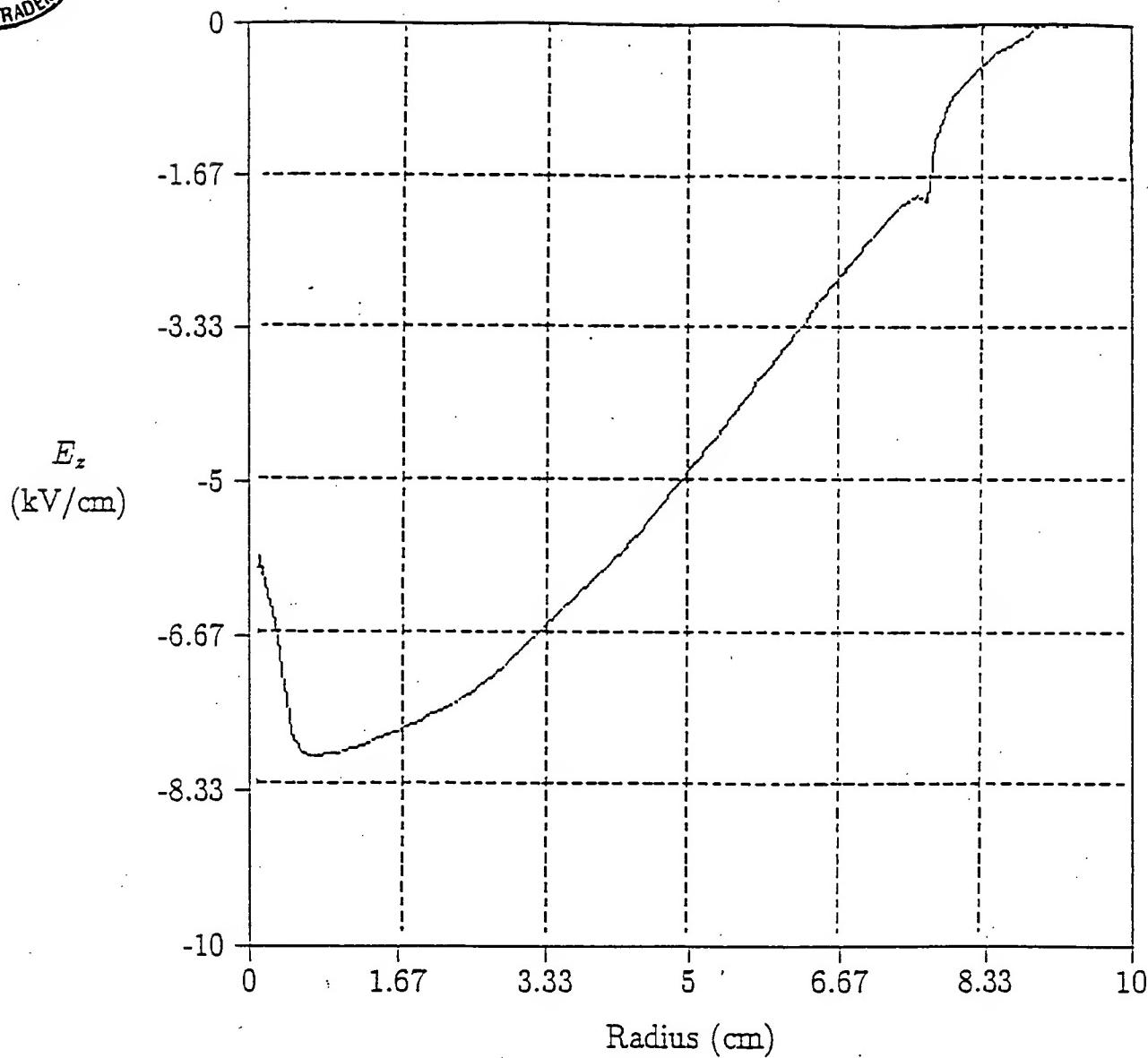


Figure 22: Axial electric field in cavity with a one cm diameter, 40 amp/cm^2 , 25 ps long beam emitted into the cavity. The curve is inverted compared to the plot of Fig. 21. However, the depression at $R = 0 \text{ cm}$ due to space charge is clearly seen. Beam loading reduces the field by about 1/3.

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Electric Field vs Radius for an Ideal and a Coaxially Fed Cavity
 TM_{020} mode at 1.275 GHz, Cavity Gap=1 cm, Coaxial Gap= 1 cm

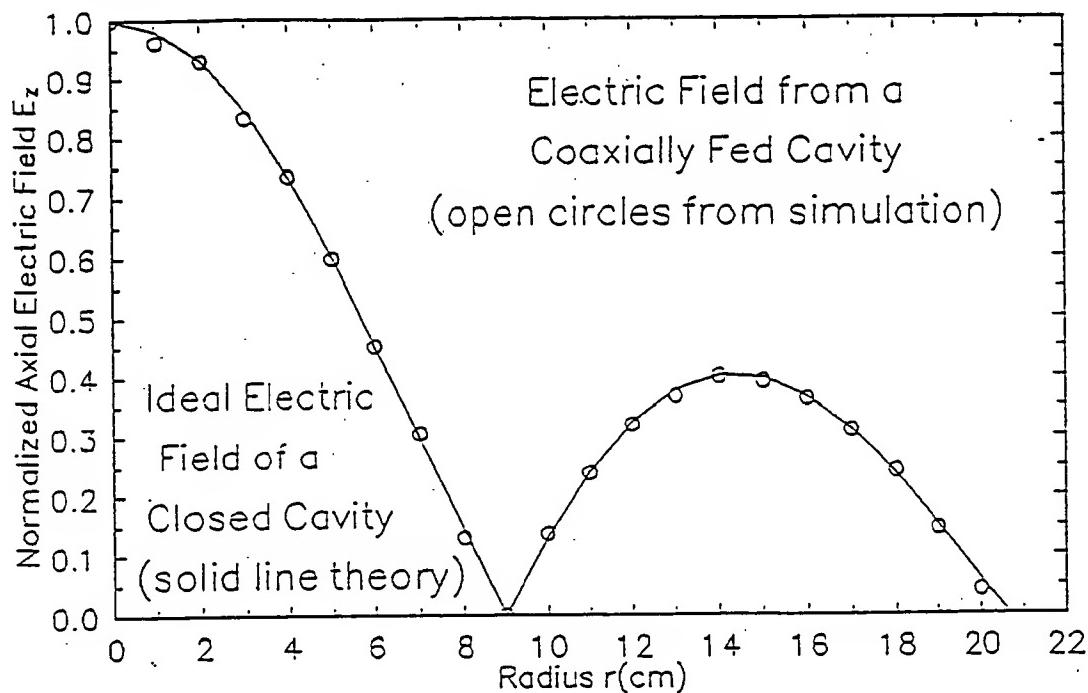


Figure 23: Electric field from a coaxially fed cavity (TM_{020} mode) showing simulation values (open circles) and theoretical curve for an ideal closed cavity.

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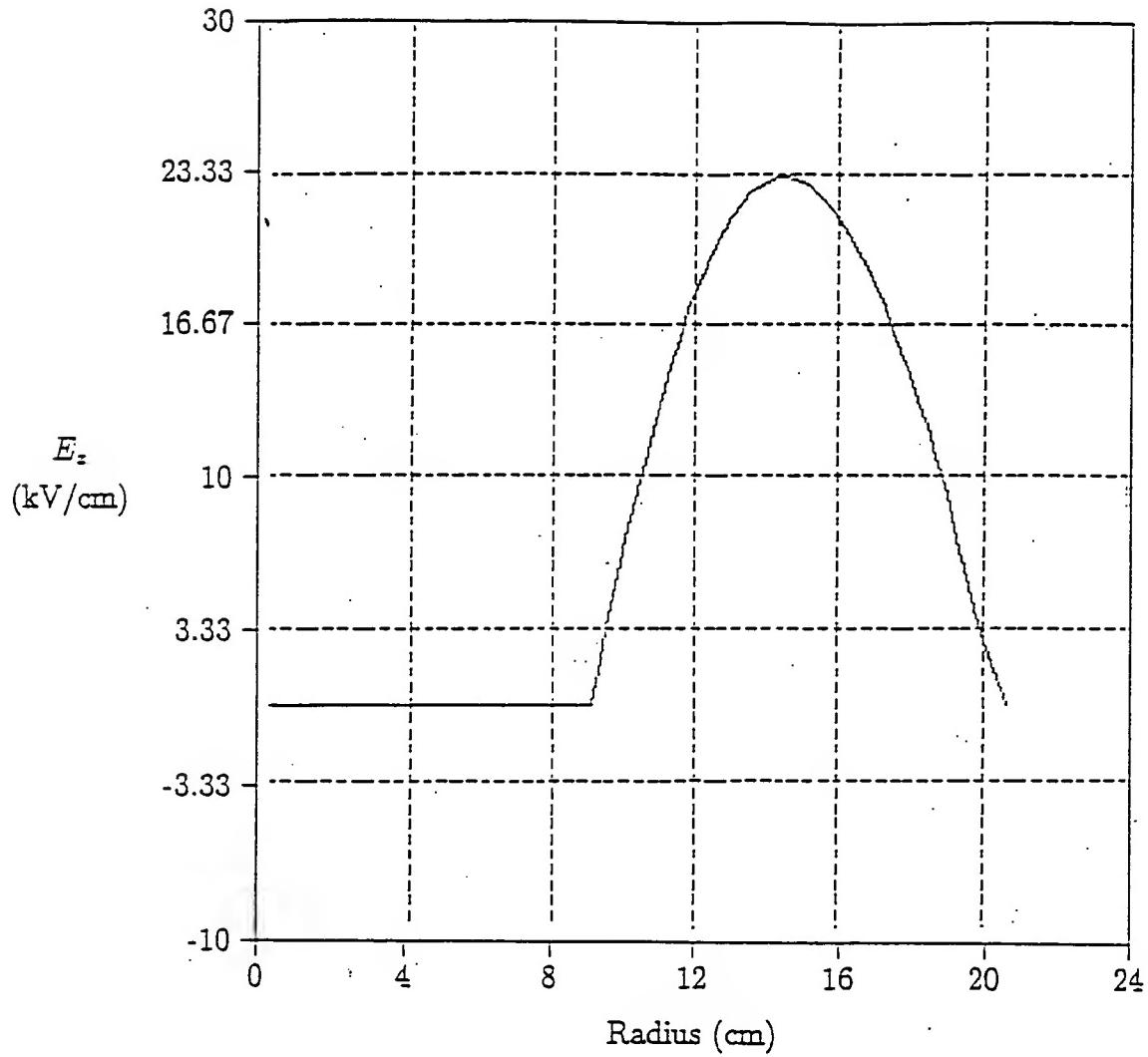


Figure 24: Axial electric field vs. radius from a coaxially fed cavity (TM_{020} mode (simulation) with inner conductor at first zero of the mode. The first peak has clearly been eliminated. Frequency 1.275 GHz and one cm gap.

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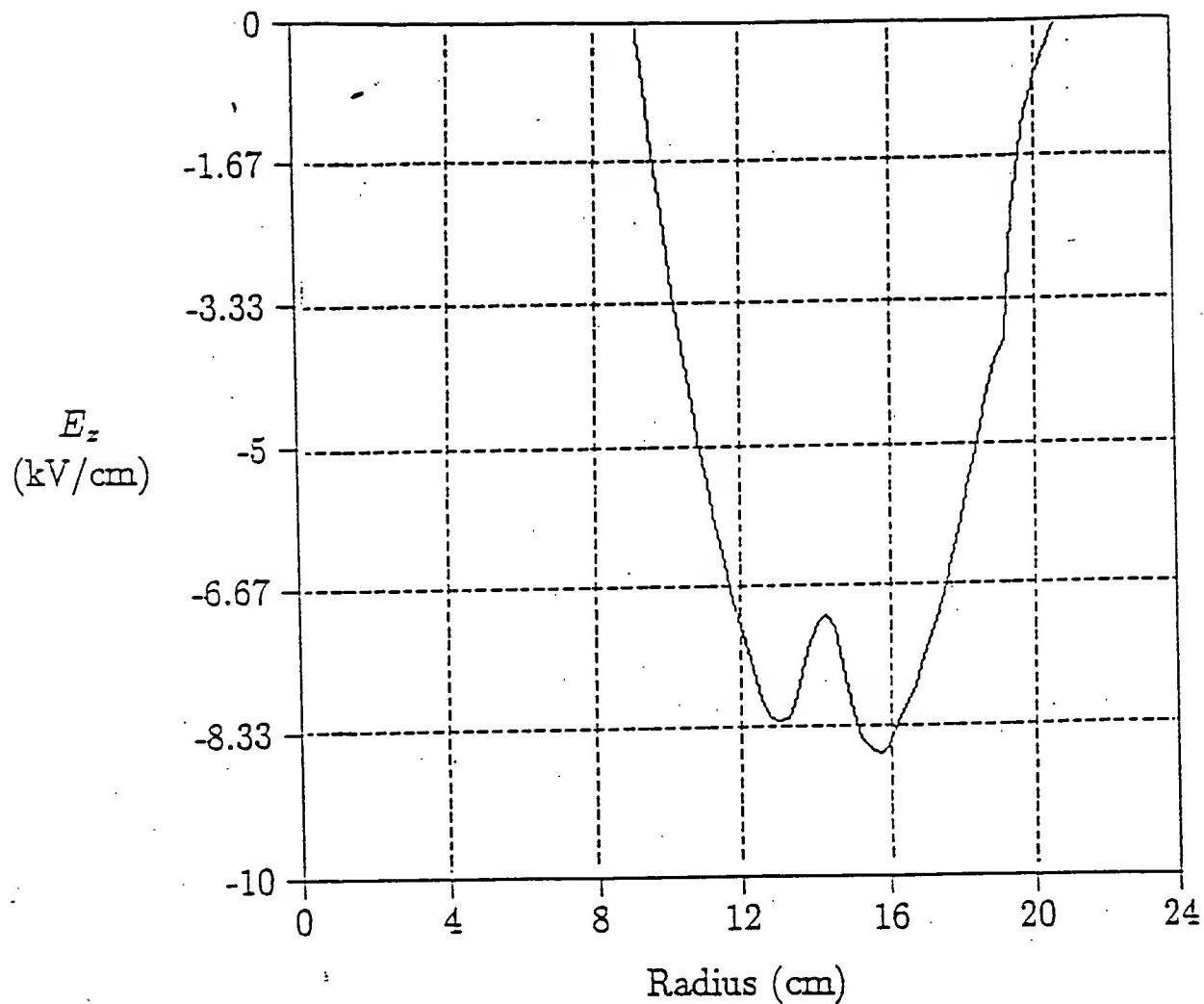


Figure 25: Axial electric field as a function of radius loaded down by a 40 amp/cm^2 , 25 ps pulse, and one cm diameter electron beam. The curve is inverted compared to the plot of Fig. 24. However, the depression at $R \approx 14 \text{ cm}$ due to space charge is clearly seen.

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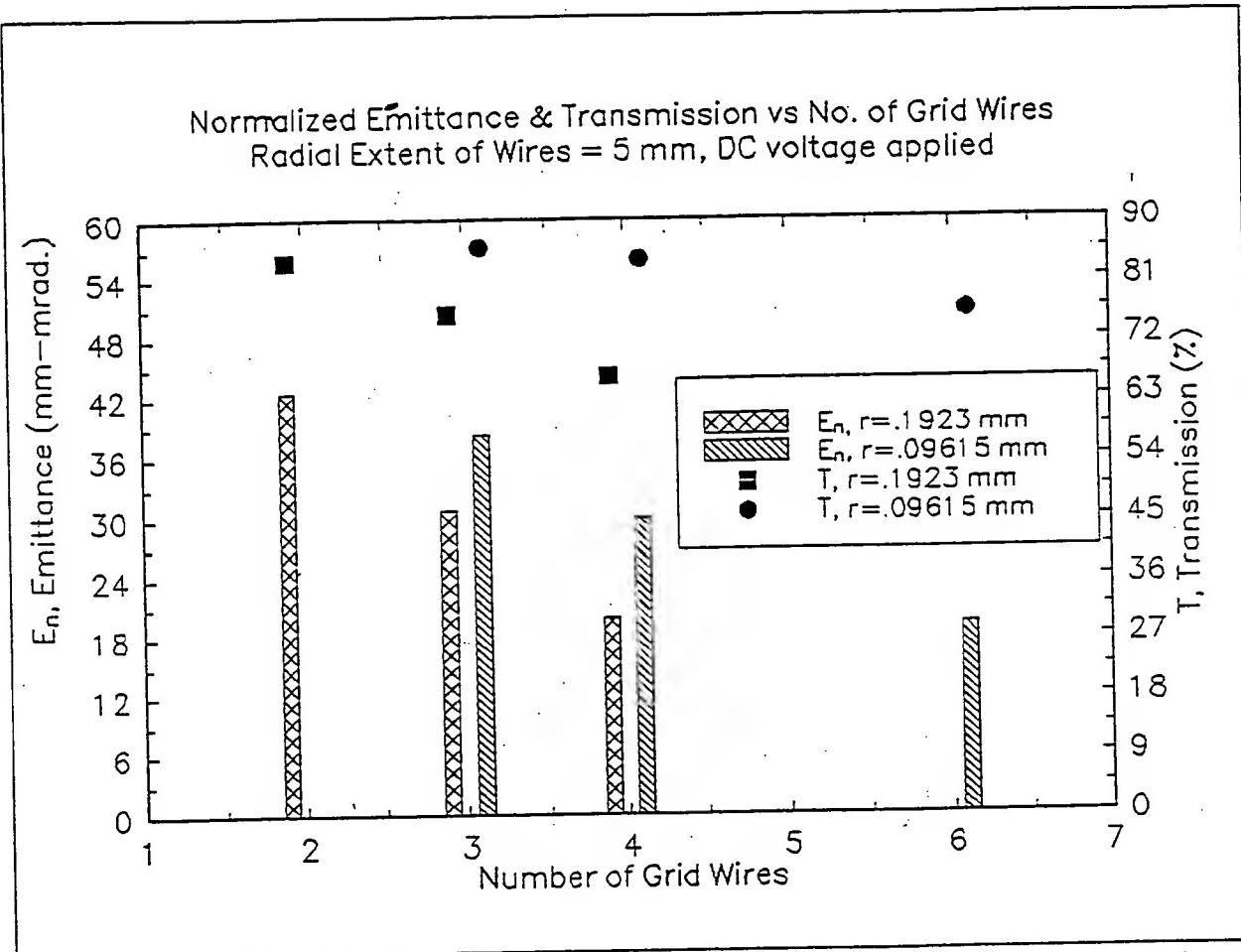


Figure 26: Normalized emmitance and transmission versus number of grid wires with a dc voltage applied to the cavity.

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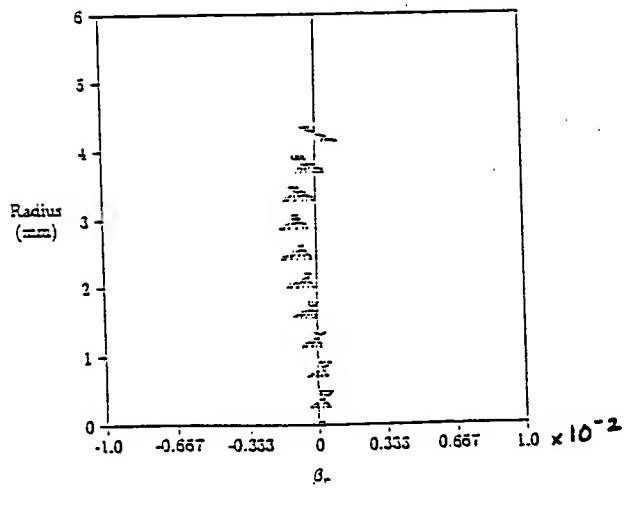
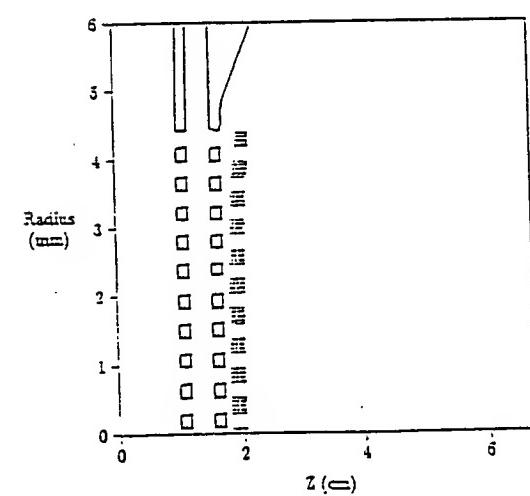
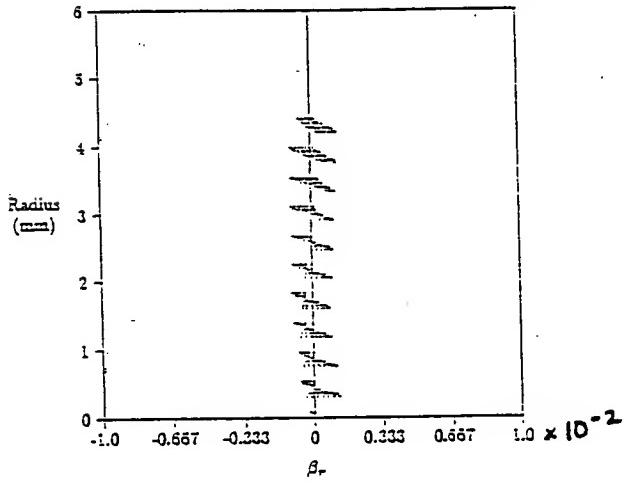
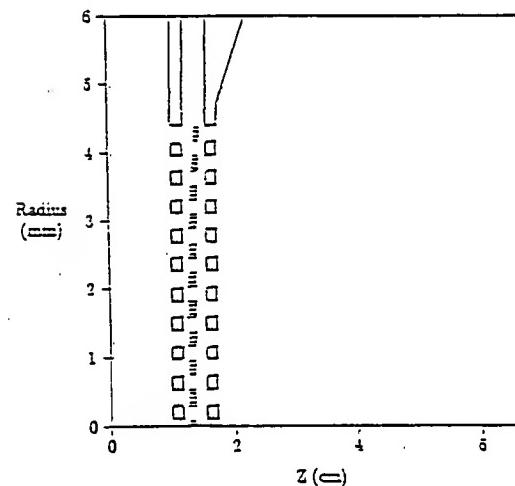
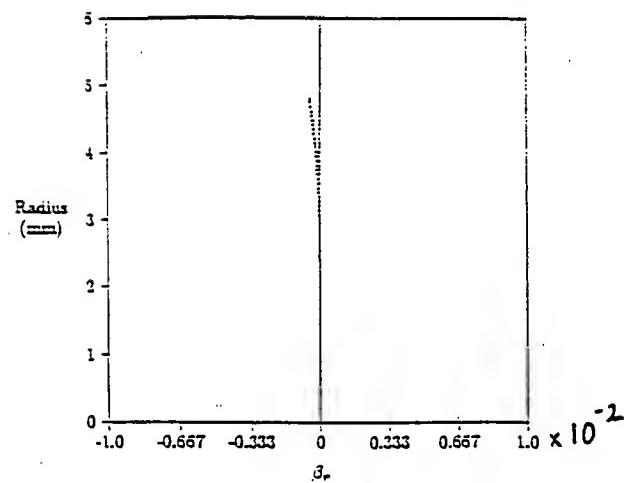
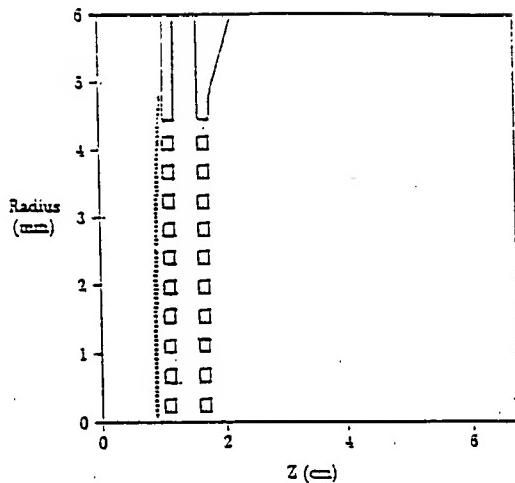


Figure 27: Configuration space and phase space for a solid beam from the simulations. This shows the emittance growth up to the first grid, from the first grid, and from the second grid.

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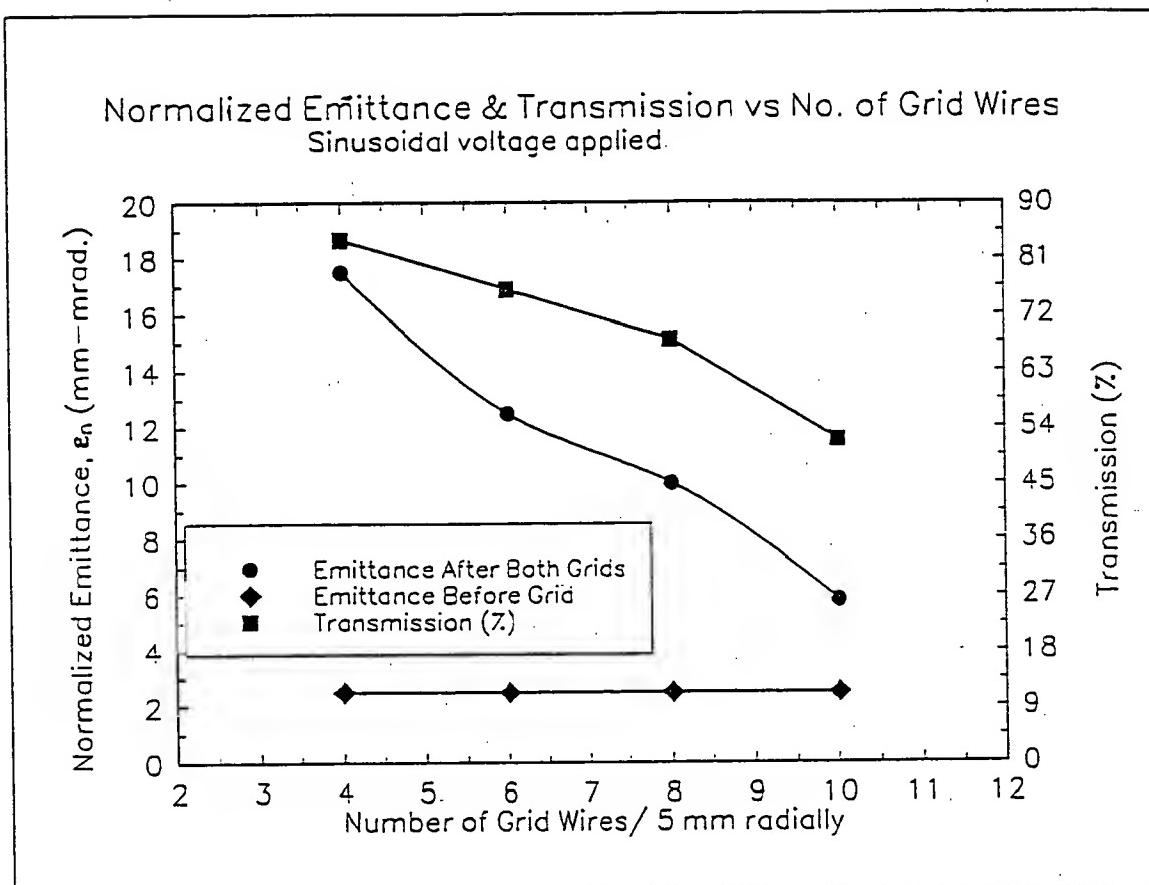


Figure 28: Normalized emittance and transmission versus number of grid wires with an ac voltage applied to the cavity. Grid wire radius is 0.09615 mm.



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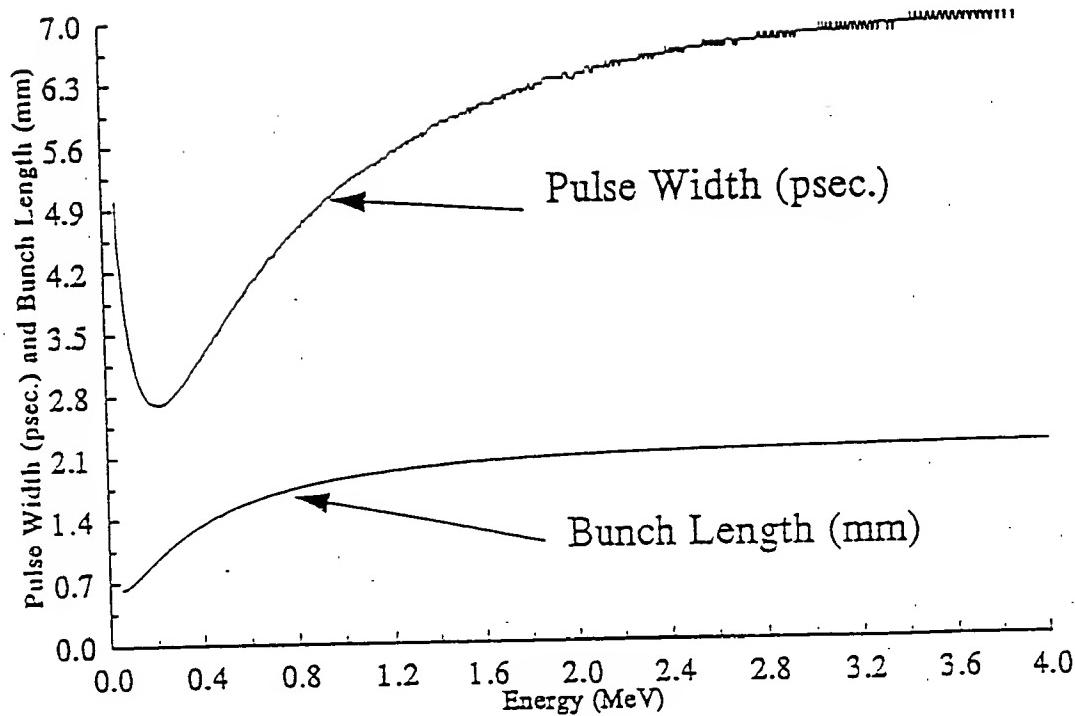


Figure 29: Expansion of micro-pulse from space charge during acceleration, neglecting energy spread. The acceleration field is 20 MV/m and the axial space charge electric field is 2.9 MV/m (corresponding to about 100 nC/cm³). The initial pulse width is 5 ps at an initial energy of 50 keV.



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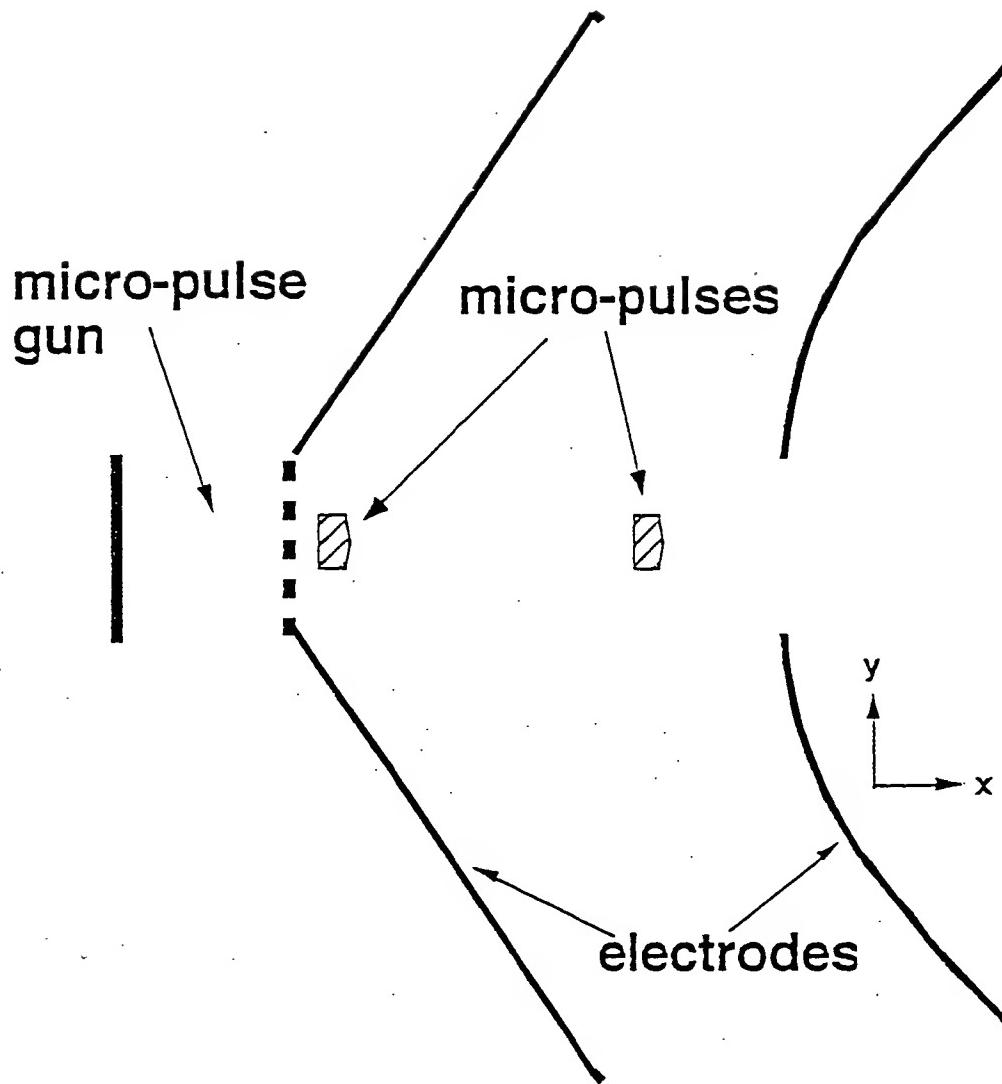


Figure 30: Schematic drawing of a set of electrode shapes for a high-power diode using the modified formulas to the usual Pierce shapes as discussed in the text.

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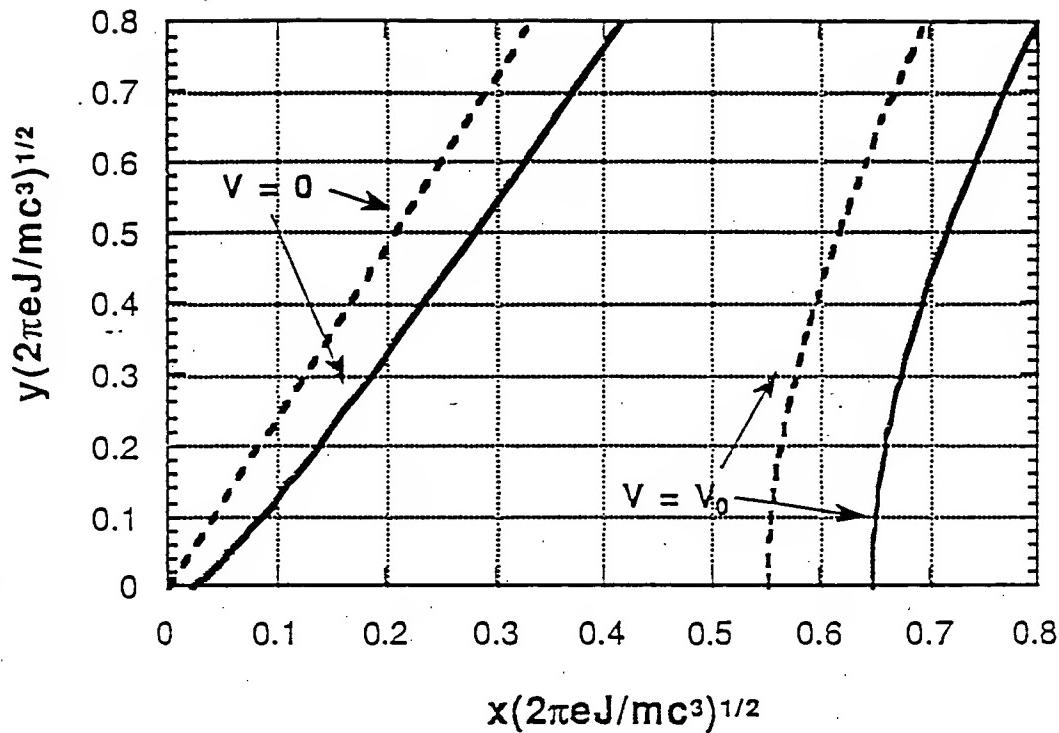


Figure 31: Plot of electrode shapes for a non-space-charge-limited 0.5 MeV diode. The modified shapes [solid lines] and the classical Pierce shapes [broken lines] are shown for comparison. The value of the electric field E_0 at the cathode is such that the quantity $\nu = 2$

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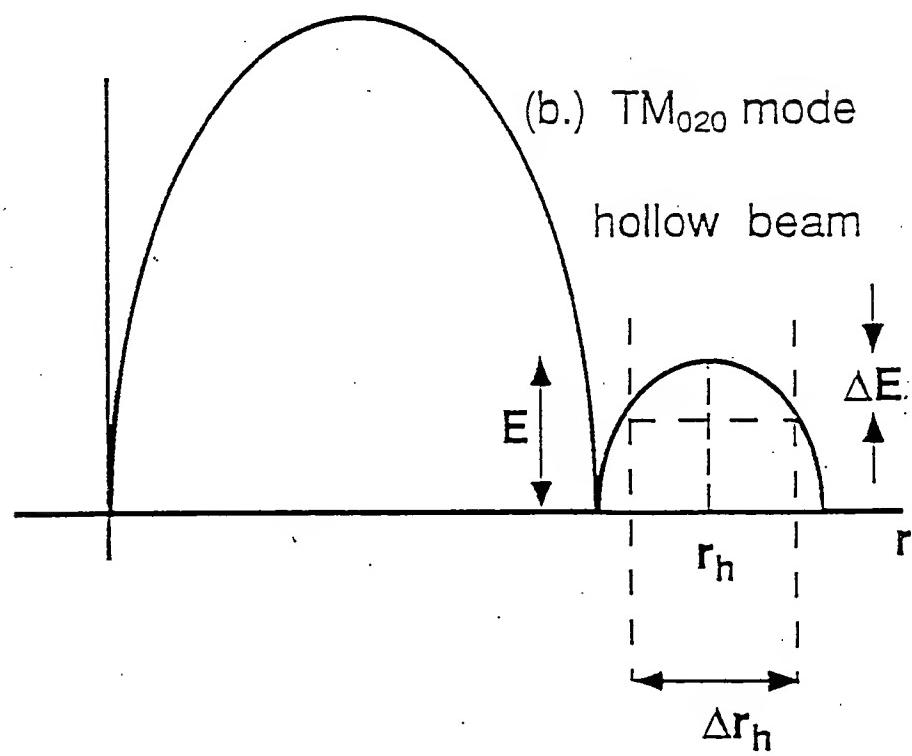
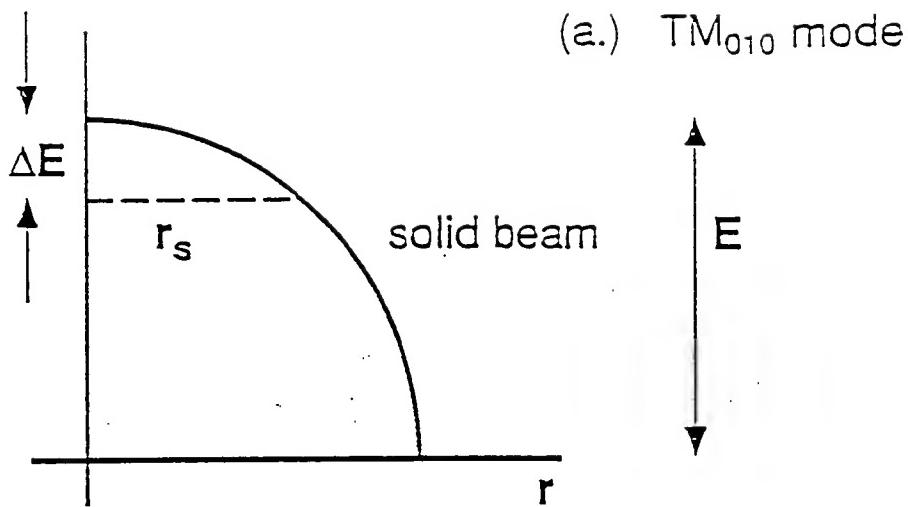


Figure 32: Schematic drawing of emission area and energy spread for a micropulse.

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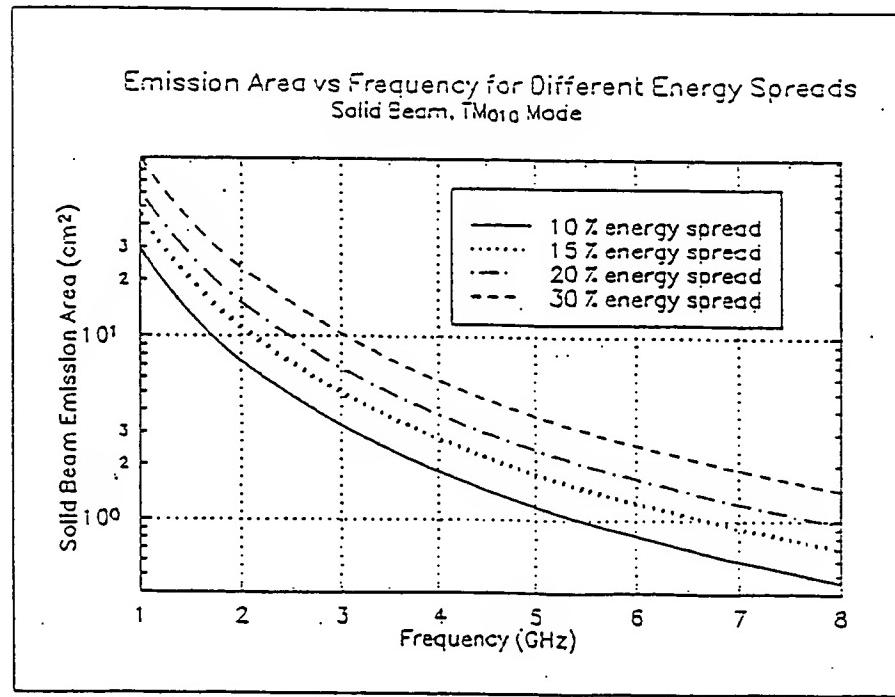
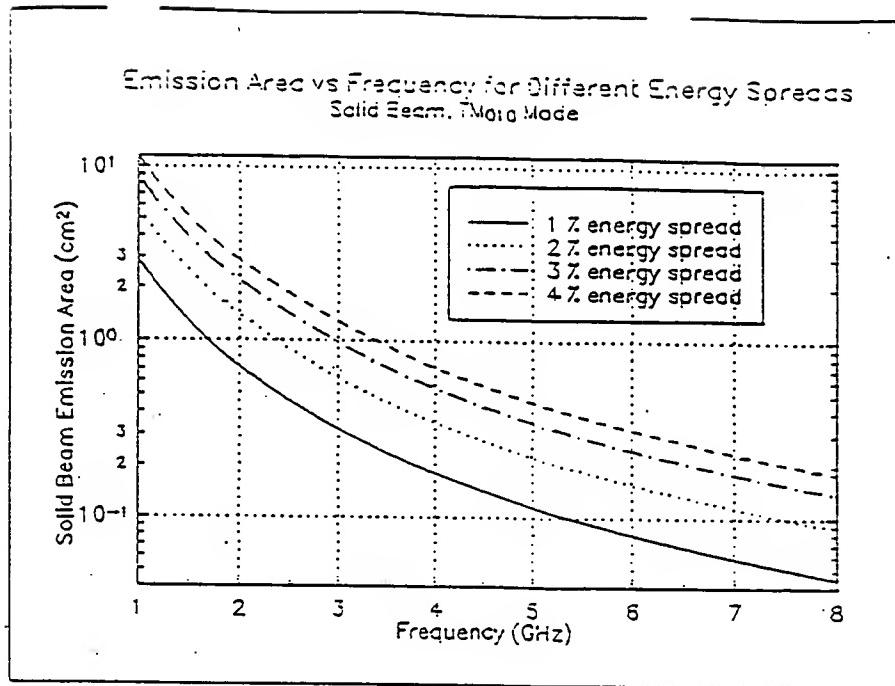


Figure 33: Emission area for a solid beam vs. frequency for different energy spreads (top) 1%-4% energy spread; (bottom) 10%-30% energy spread.

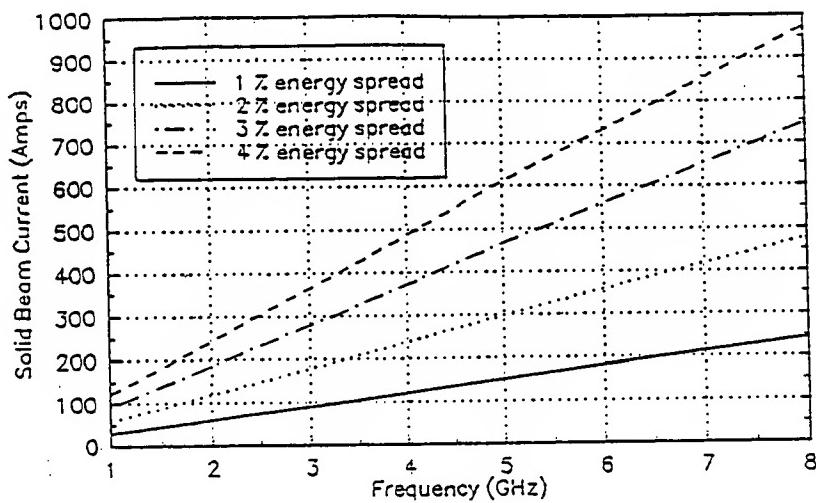
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Beam Current vs Frequency for Different Energy Spreads
Solid Beam, TM₀₁₀ Mode, $\alpha_0=0.453$, d=0.5 cm



Beam Current vs Frequency for Different Energy Spreads
Solid Beam, TM₀₁₀ Mode, $\alpha_0=0.453$, d=0.5 cm

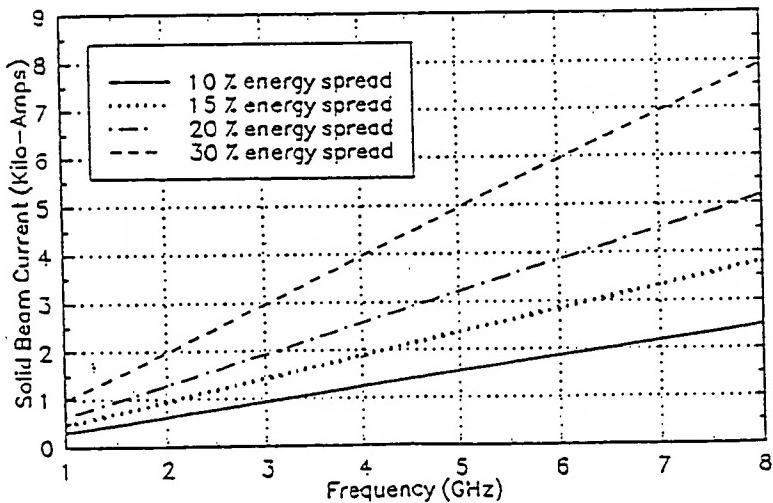


Figure 34: Beam current (solid beam) vs. frequency for different energy spreads and a gap of 0.5 cm.

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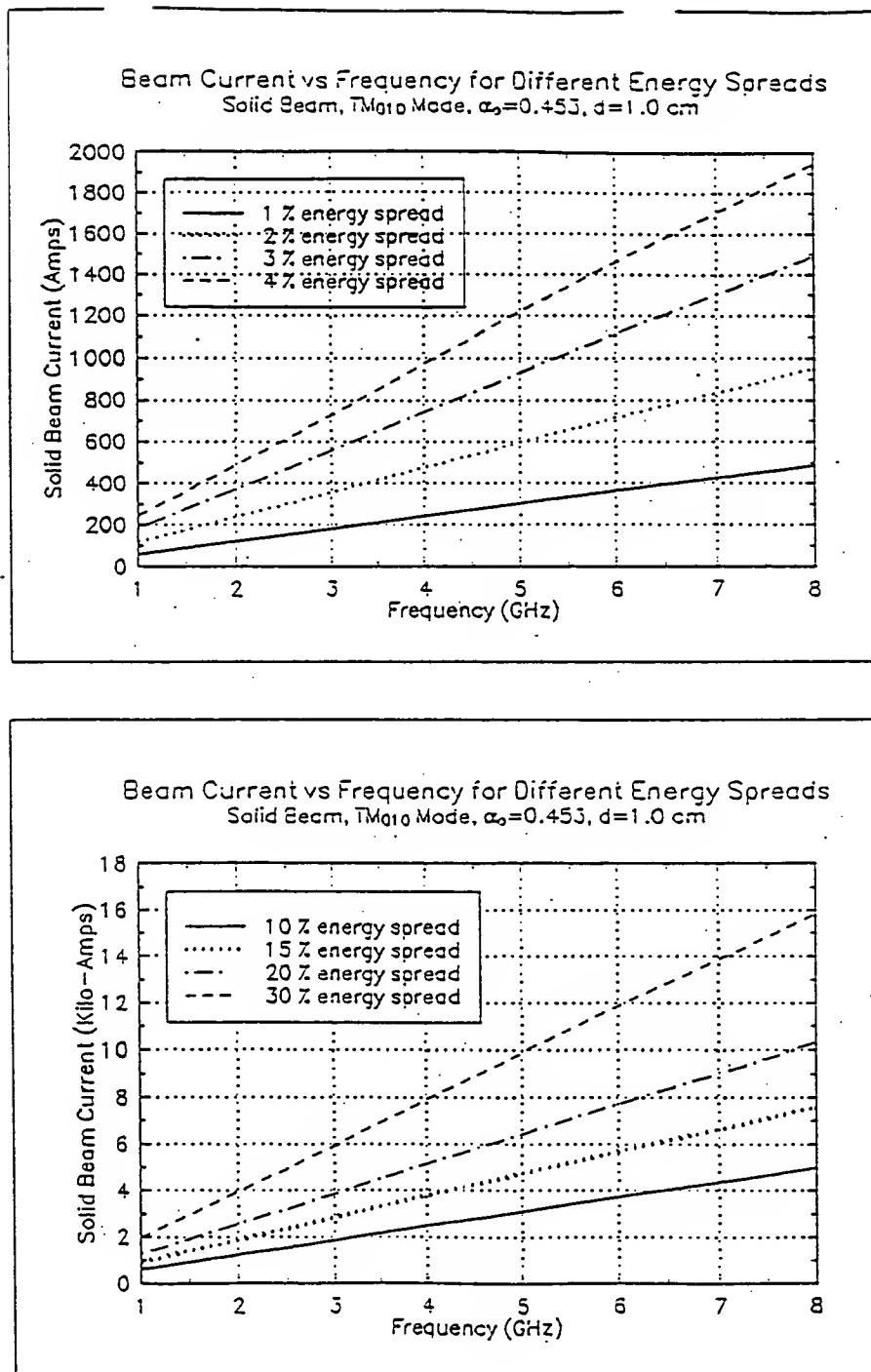


Figure 35: Beam current (solid beam) vs. frequency for different energy spreads and a gap of 1.0 cm.



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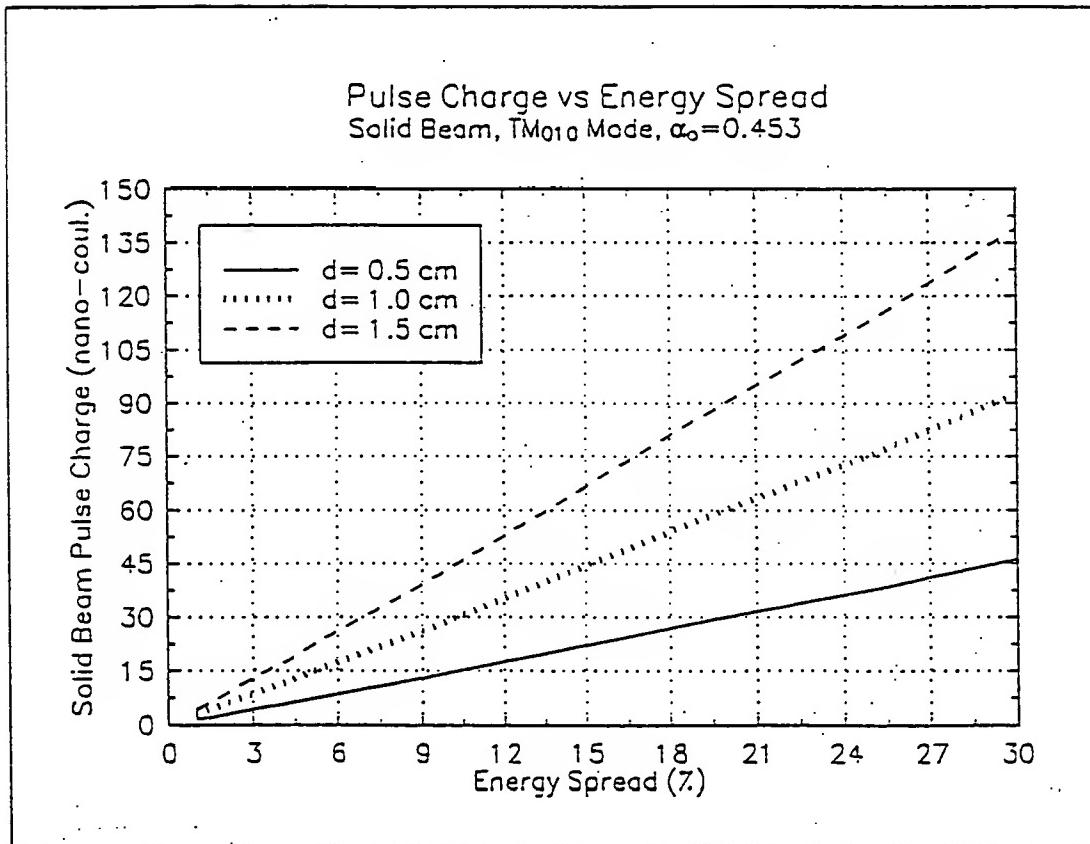


Figure 36: Charge per pulse for a solid beam vs. energy spread.

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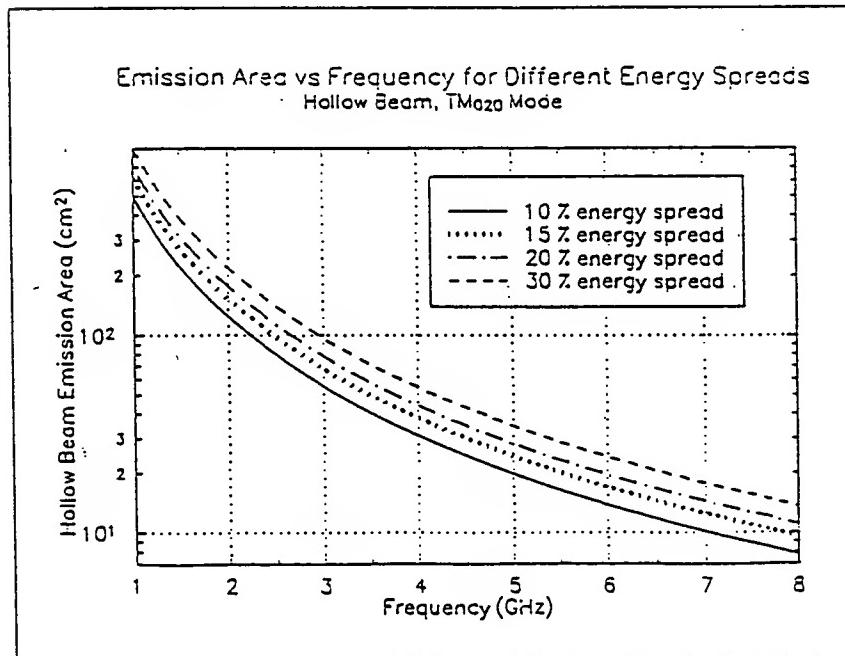
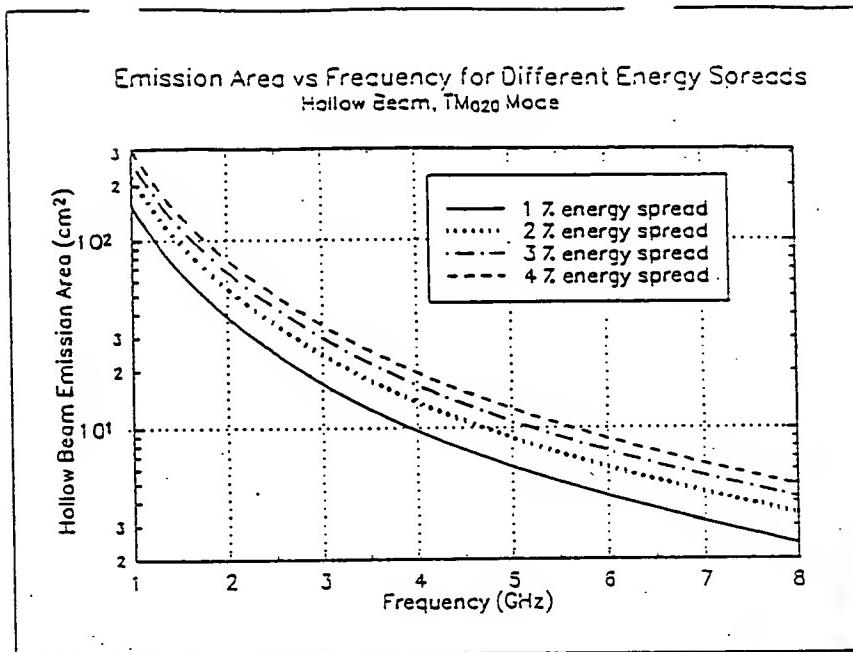


Figure 37: Emission area vs. frequency for different energy spreads. Hollow beam.



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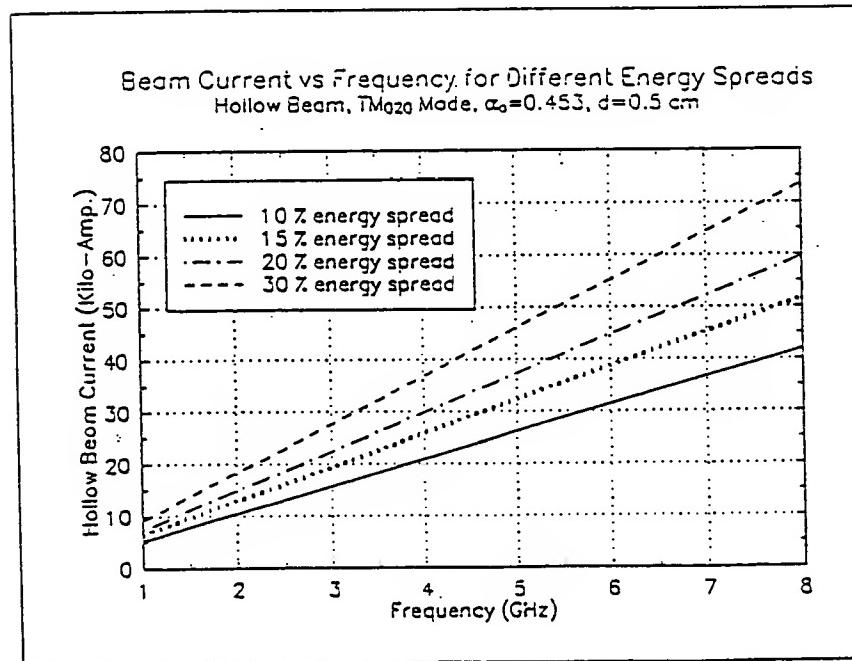
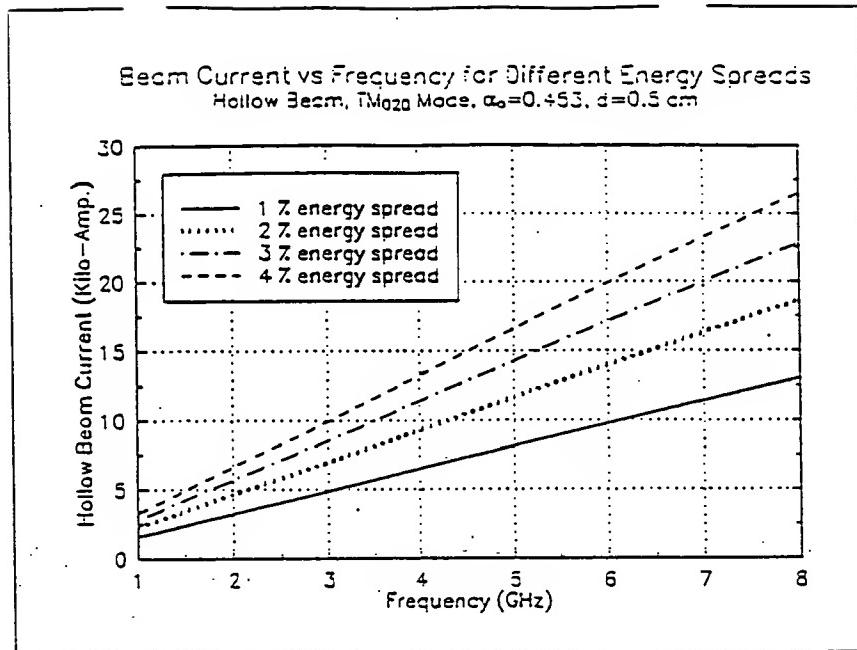


Figure 38: Beam current vs. frequency for different energy spreads. Hollow beam, and $d = 0.5$ cm.

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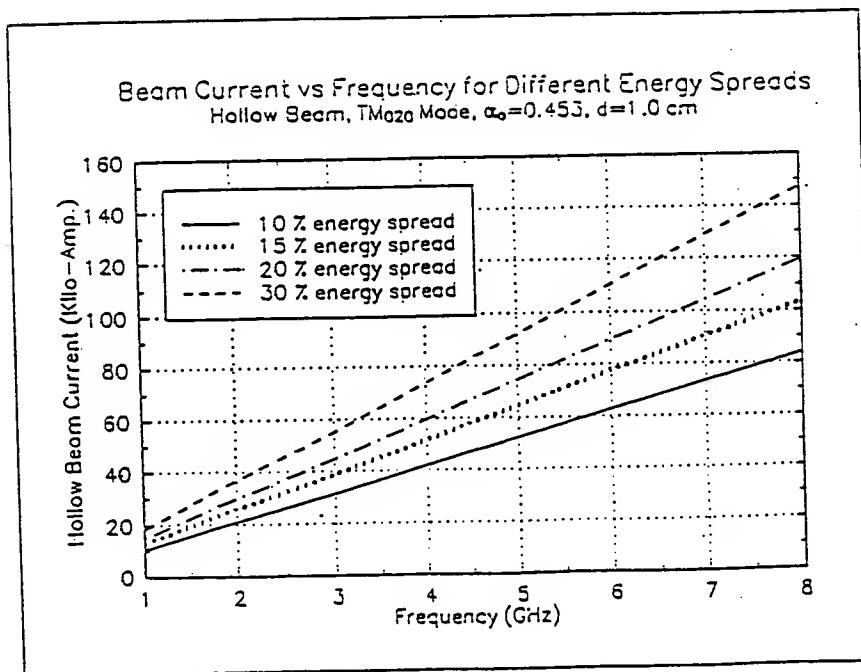
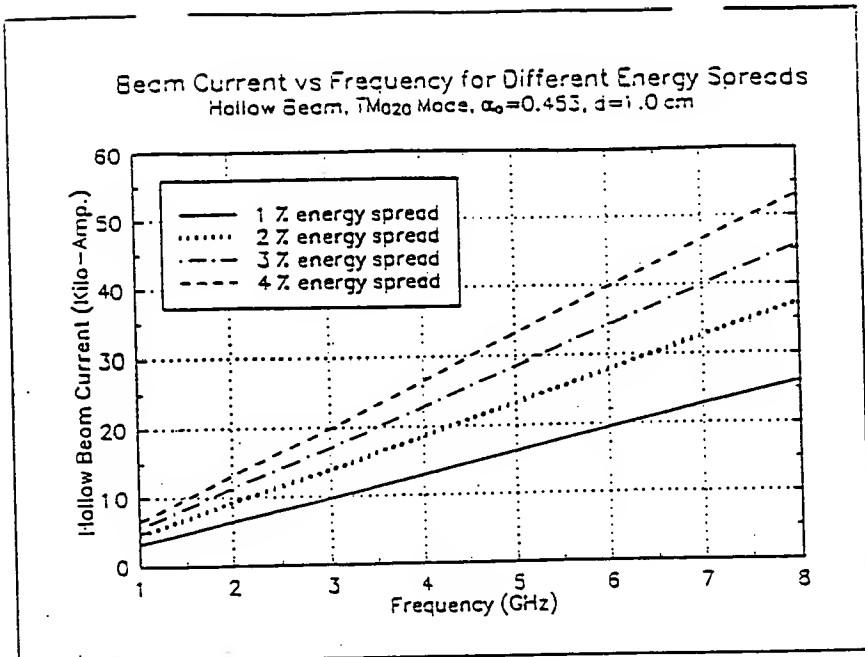


Figure 39: Beam current vs. frequency for different energy spreads. Hollow beam, and $d = 1.0$ cm.



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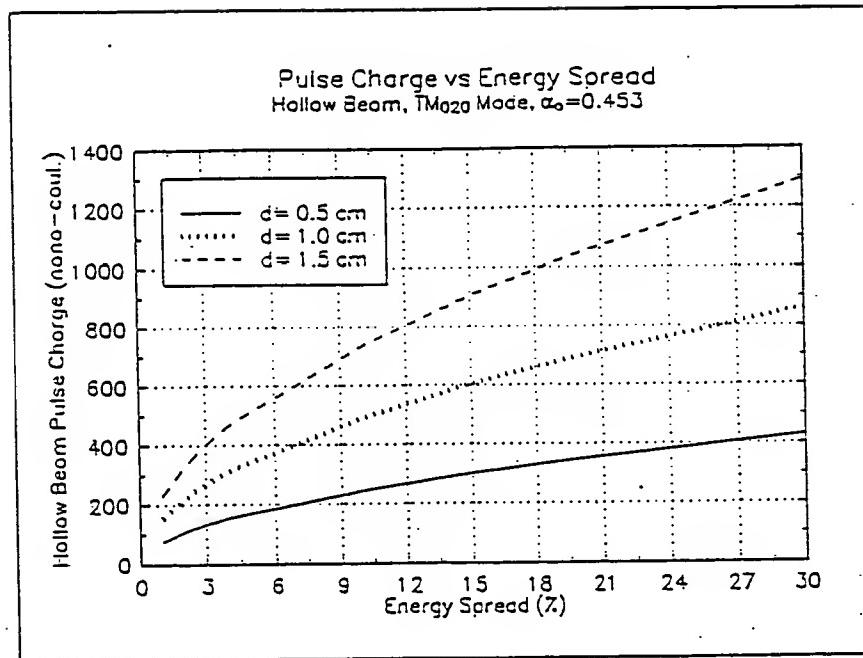


Figure 40: Pulse charge vs. energy spread for hollow beam.

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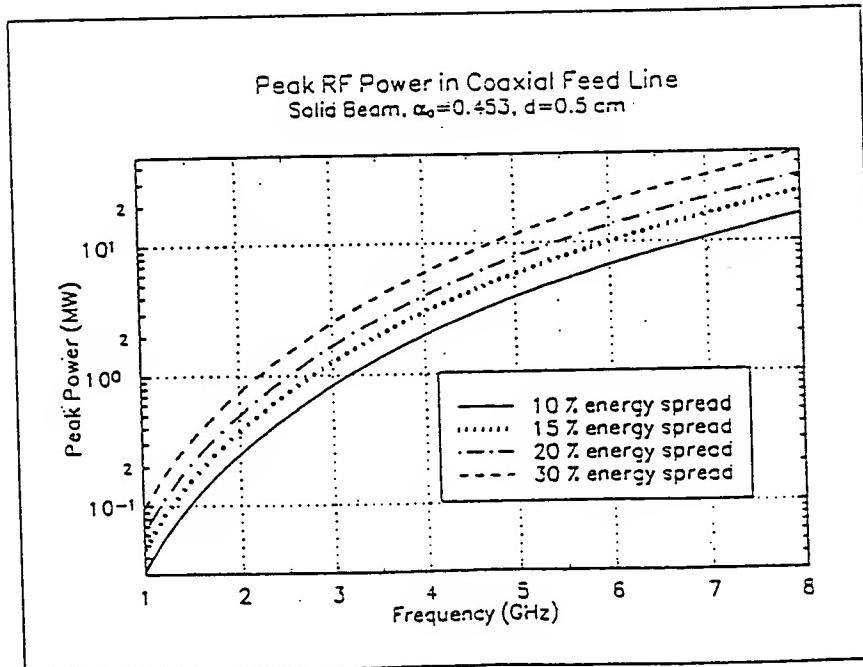
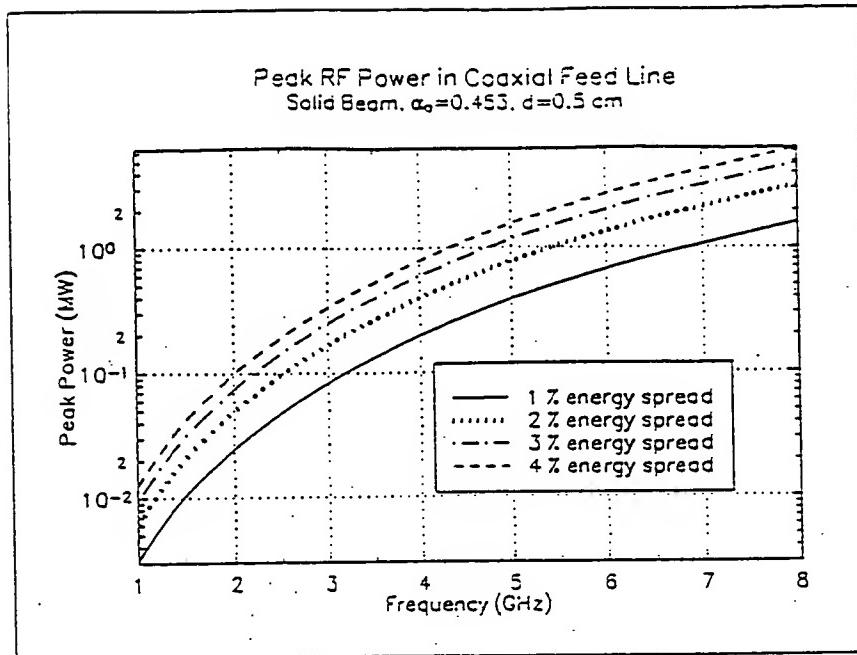


Figure 41: Peak rf power in coaxial feed line for a solid beam, $d = 0.5$ cm.

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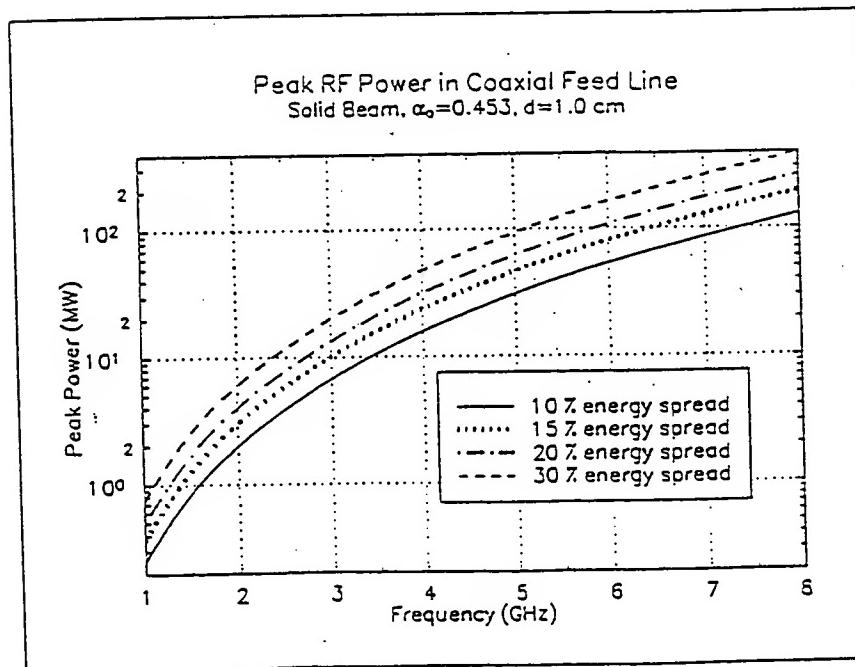
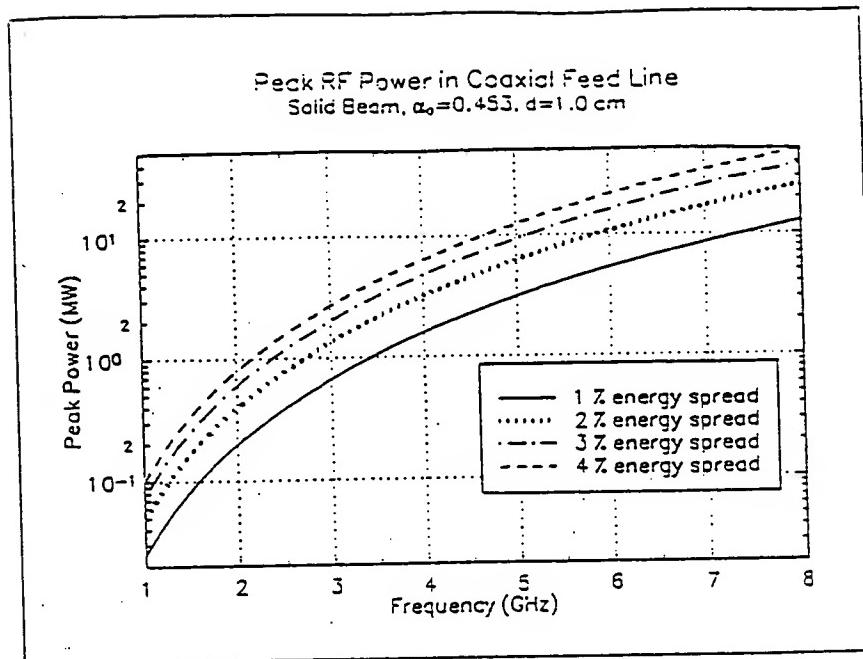


Figure 42: Peak rf power in coaxial feed line for a solid beam, $d = 1.0$ cm.



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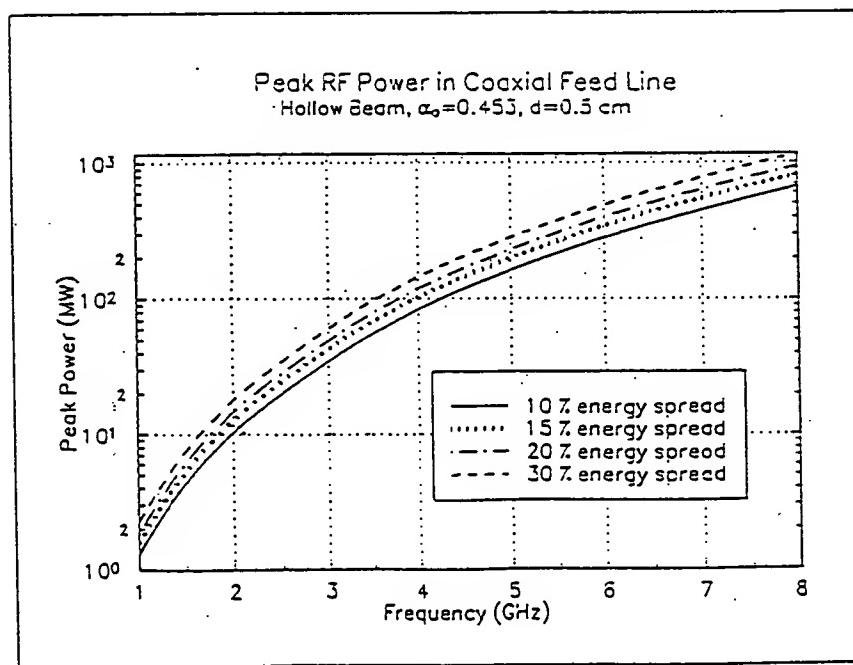
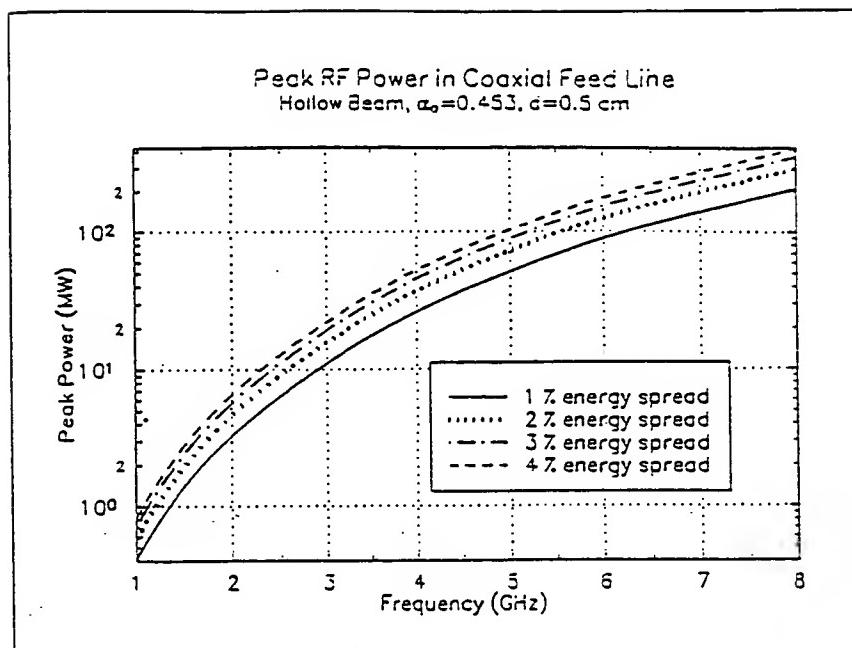


Figure 43: Peak rf power in coaxial feed line for a solid beam, $d = 0.5$ cm.

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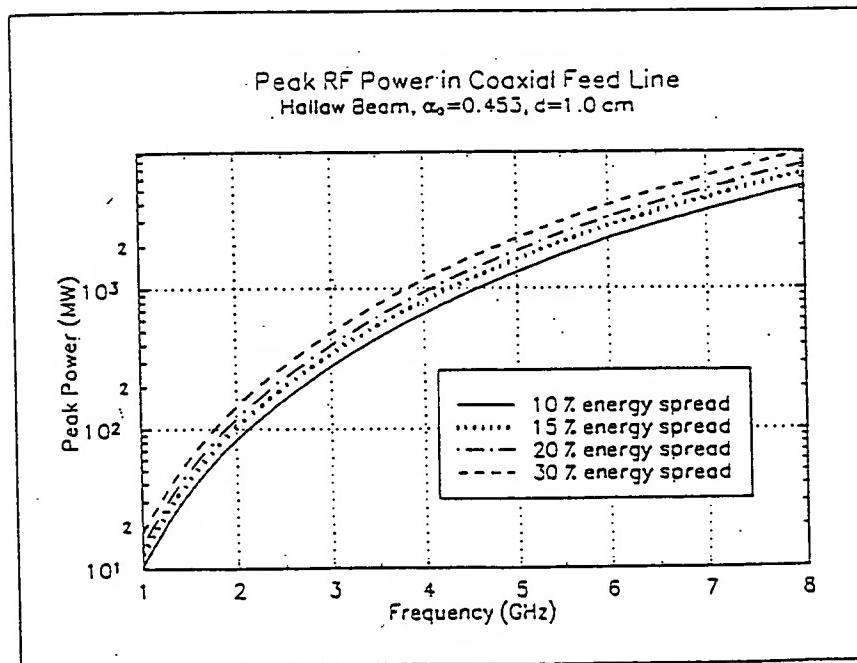
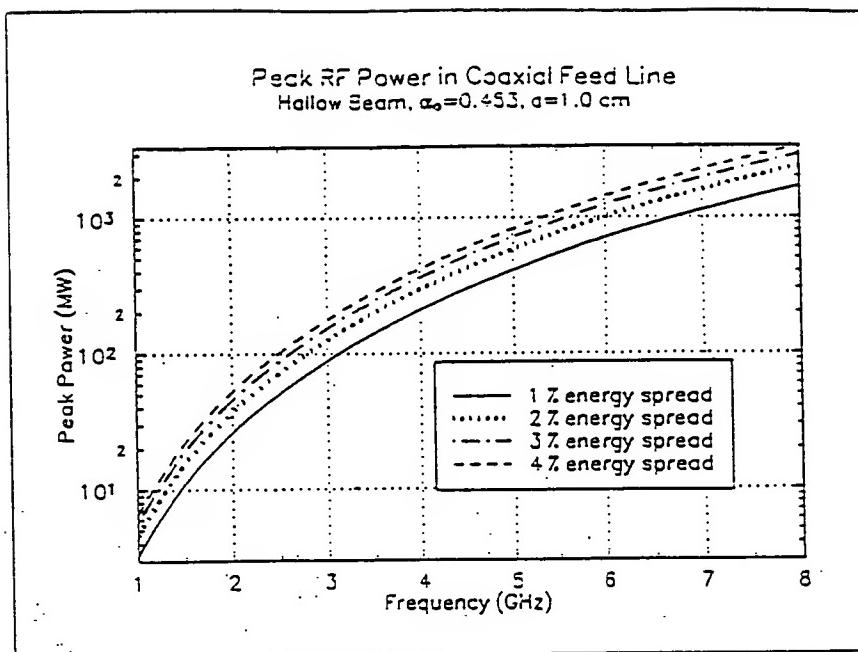


Figure 44: Peak rf power in coaxial feed line for a solid beam, $d = 1.0$ cm.

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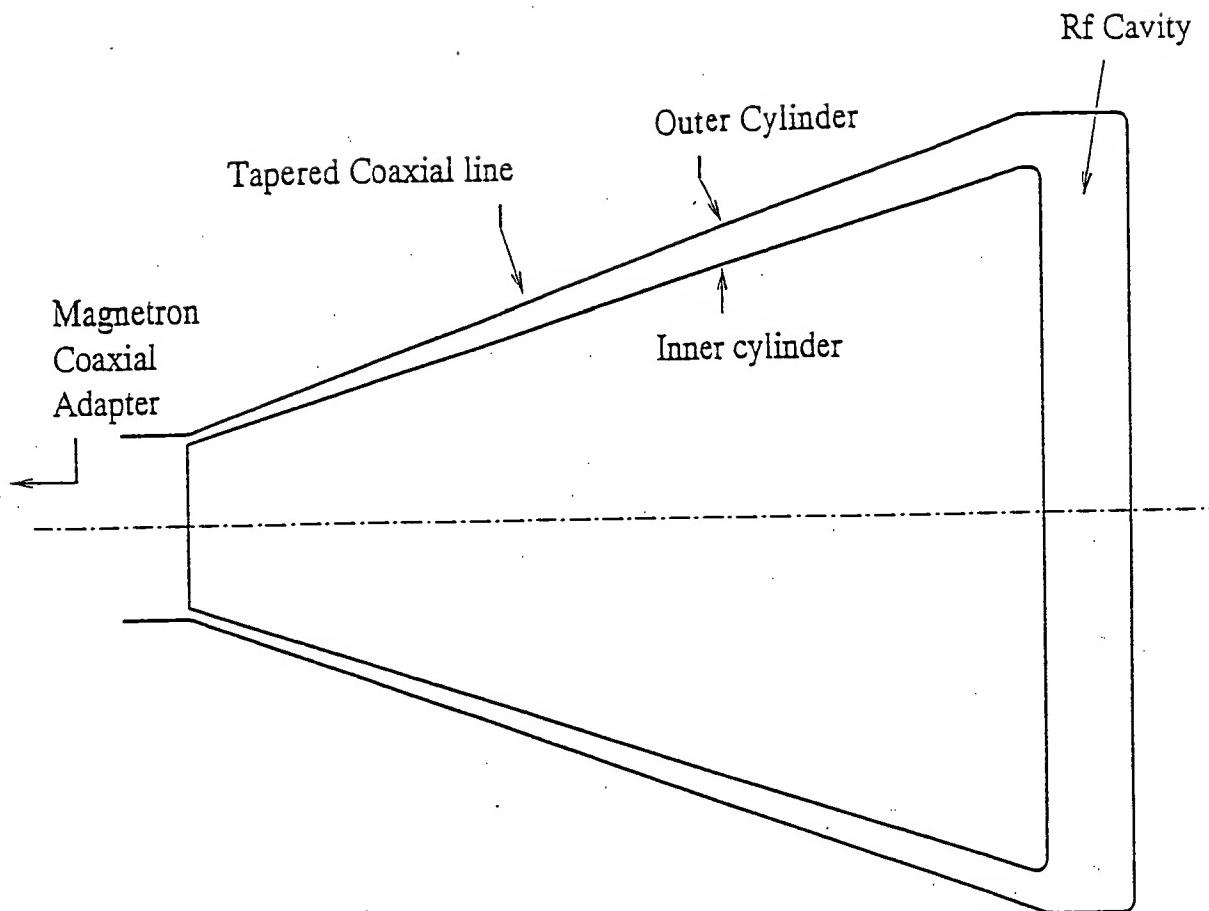


Figure 45: A magnetron feeding energy into the rf cavity. For simplicity a constant, low impedance, coaxial feed line is assumed. Voltage step-up occurs in the rf cavity.



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RF cavity
(side view)

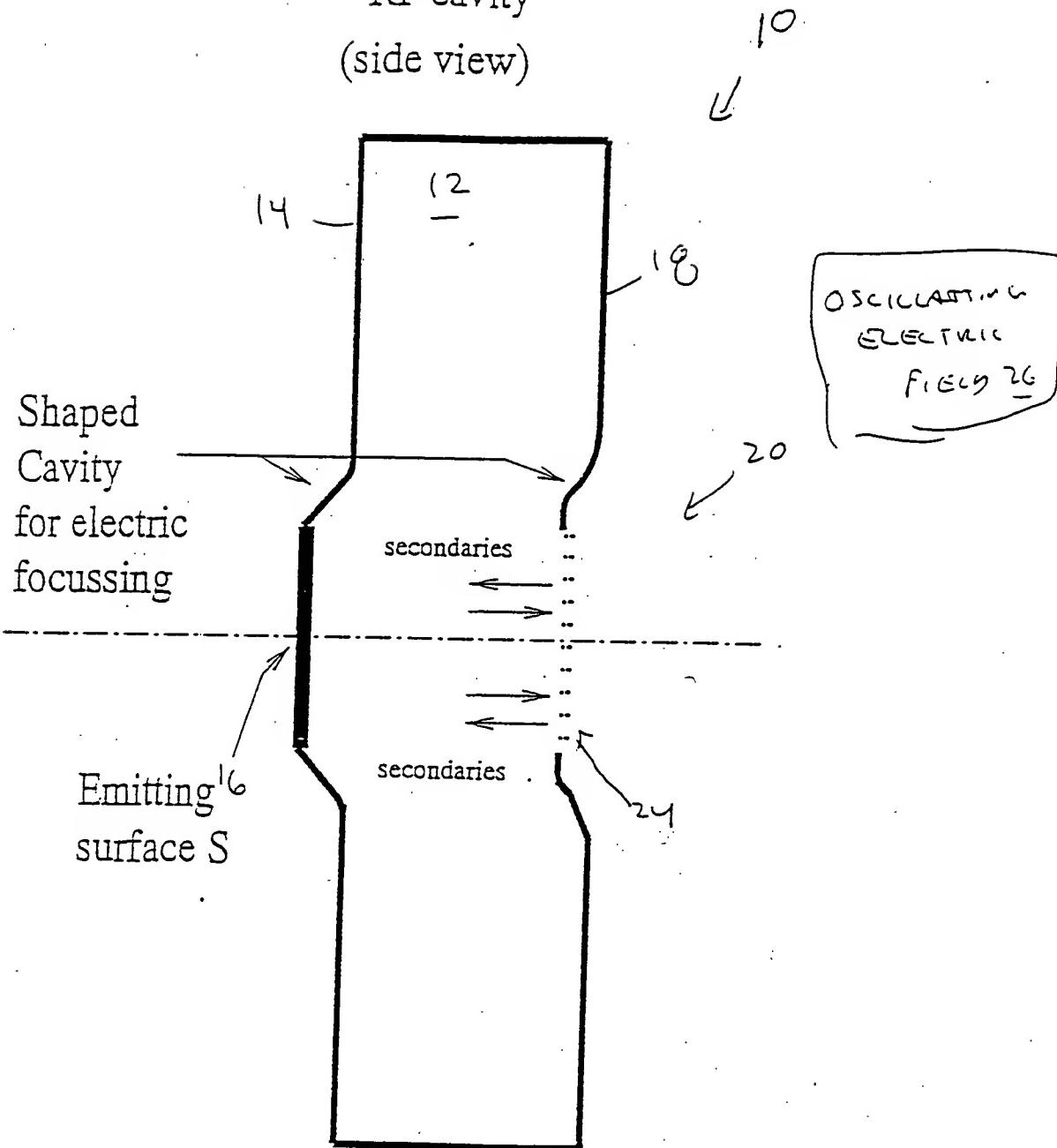


Figure 46: Schematic drawing of a possible design for electrostatic focusing in the MPG.